Ref. Ares(2025)3453003 - 29/04/2025

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

Grant Agreement Number: 101003890 Call identifier: **H2020-LC-CLA-2018-2019-2020**	
Topic:	LC-CLA-15-2020 Forest Fires risk reduction: towards an integrated fire management approach in the E.U.
Instrument:	RIA

D5.12 – Position paper on the results for fire risk assessment, reduction and adaptation

Deliverable Identifier:	D5.12
Deliverable Due Date:	29/02/2025
Deliverable Submission Date:	25/04/2025
Deliverable Version:	v.1.0
Lead partner:	GMV Aerospace (GMV)
Authors:	Julia Yagüe-Ballester, Antonio Franco-Nieto, Marta Gómez-Giménez
Work Package:	WP5 - Pilot Sites and Demonstration Areas
Task:	Task 5.2 – Management of study cases
Dissemination Level:	☒ PU: Public ☐ CO: Confidential, only for members of the Consortium (including the Commission Services)

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

Revision History

Version	Date	Edited by	Description
v.0.1	DD/12/2024	GMV	Document Content outline / structure
v.0.2	DD/01/2025	GMV	Draft version
v.0.3	10/02/2025	GMV	Complete version formatted according to template
v.0.4	26/03/2025	GMV	Complete version with Annexes
v.0.5	01/04/2025	GMV	Complete draft review by WP5 Leader
v.0.6	11/04/2025	SC	Internal review of the Complete version
v.0.7	21/04/2025	GMV	Comments by internal reviewers (CM, GE), implemented
v.0.9	24/04/2025	CSIC/SU	Internal approval review by the QRB
v.1.0	25/04/2025	GMV	Final version submitted

Quality Control

Type	Date	Reviewed by	Approved/Comment
Internal	14/04/2025	Christopher Marrs	All comments implemented
Internal	21/04/2025	Georgios Eftychidis	All comments implemented
Internal	24/04/2025	Juli Pausas. Stefan Doerr, QRB	All comments implemented

Copyright © FirEUrisk Consortium. All rights reserved.

0. Executive Summary

Document in a nutshell

This document synthesises the tangible solutions attained during the demonstration events, carried out in the Demonstration Areas (DA), Pilot Sites (PS) and European Territory (ET) showcasing the viability and limits of practically addressing the integrated wildfire risk management (IWRM) strategy. These findings directly support EU policy priorities on climate adaptation, environmental protection, and cross-border crisis management by providing evidence-based frameworks and tools for policymakers at all governance levels

How to read this document

Reduced reading: focus on the Executive Summary and Chapter 7 *Position statements*.
Complete reading: follow the table of contents.
Reading of technical specifications: focus on Chapters 3 to 6.

Graphic Summary

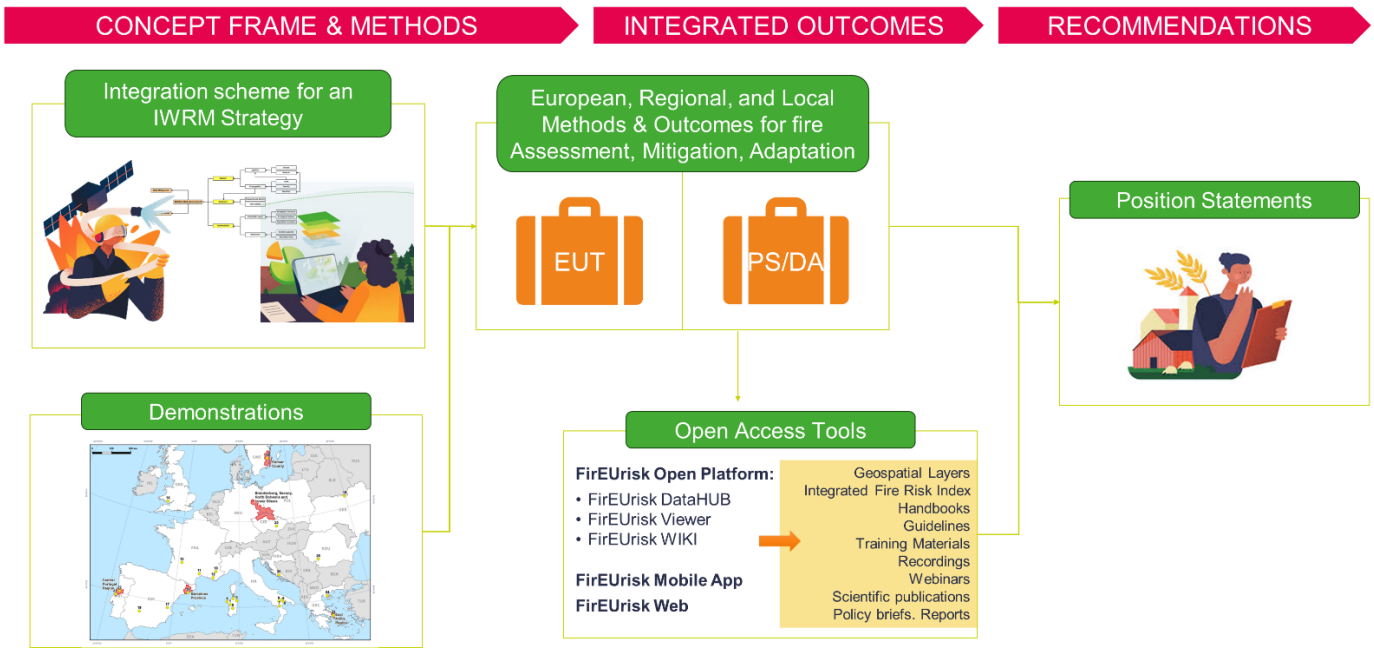


Figure 1. Graphic summary of D5.12 contents.

Copyright © FirEUrisk Consortium. All rights reserved.

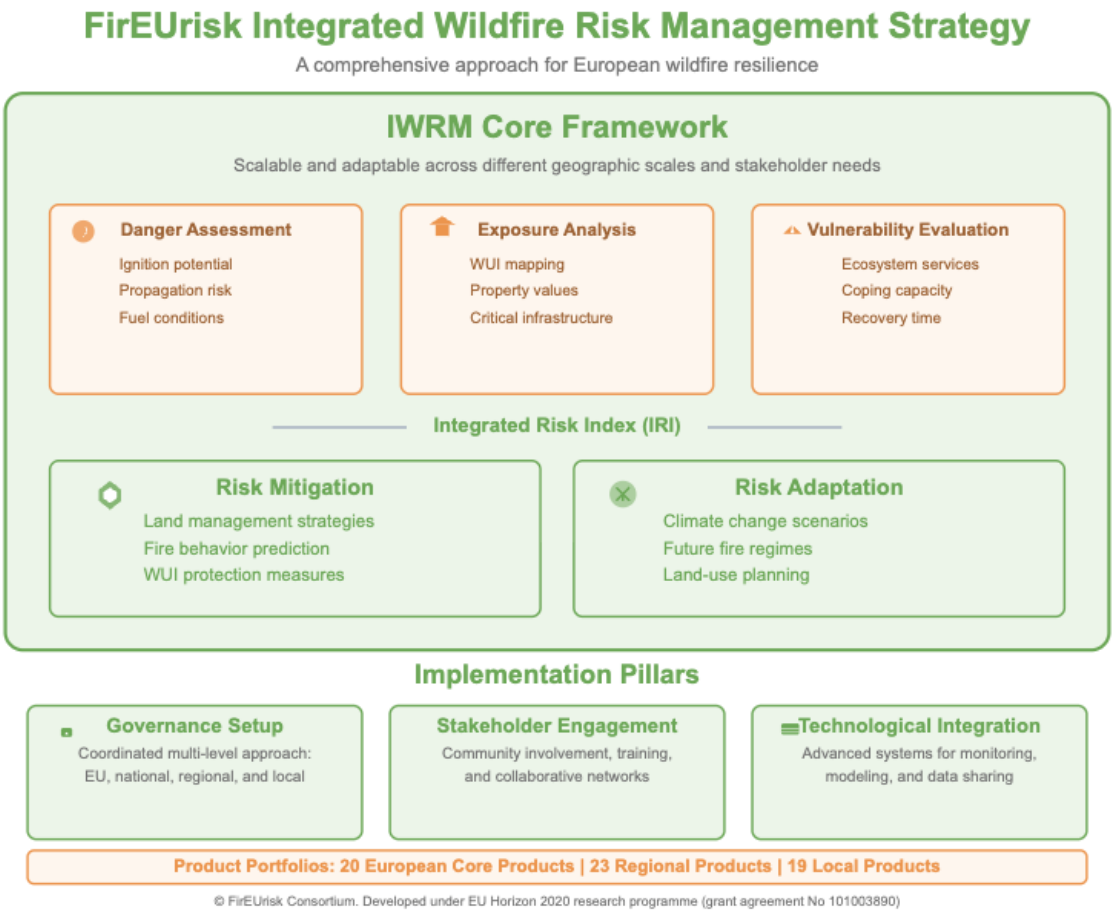


Figure 2. Structure of the FirEUrisk Integrated Wildfire Risk Management Strategy framework

Summary

This document summarises the **conceptual and tangible results/solutions/products** attained by FirEUrisk in seeking an Integrated Wildfire Risk Management (IWRM) strategy. These solutions offer policymakers concrete pathways to implement the EU's disaster risk reduction framework and strengthen wildfire resilience across diverse European contexts, directly supporting the European Green Deal and the EU Climate Adaptation Strategy.

The **concept** of the strategy refers to: (1) the **conceptual frame** for the integration, (2) the **keynote elements** of the integrated strategy, and (3) the outcomes of the **demonstration** events of such wildfire risk products held for the European territory and for the five regional pilot concept sites. (See Chapters 1 and 2). This integrated framework offers policymakers a scientifically robust structure to harmonize national and regional approaches to wildfire management and provides a foundation for developing coherent EU-wide policies.

The sixty-two (62) **solutions/products** capable of supporting the Integrated Wildfire Risk Management Strategy in practical terms include:

- The Portfolio of European Core Products (Chapter 3) - providing standardized tools for EU-wide policy implementation

Copyright © FirEUrisk Consortium. All rights reserved.

- The portfolio of Regional Products (Chapter 4) - enabling tailored approaches for national and regional authorities
- The portfolio of Local Products (Chapter 5) - supporting municipal decision-makers with targeted local interventions

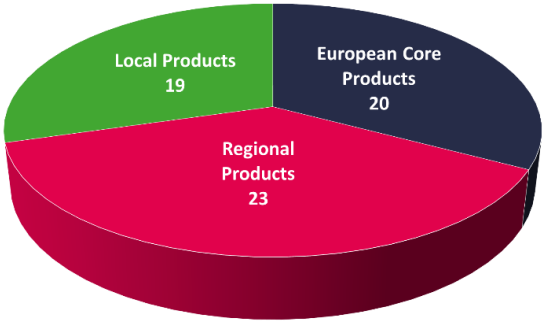


Figure 3. FirEUrisk product portfolios

The three portfolios include the same categories of products relative to the conceptual wildfire cycle: danger, exposure, vulnerability, assessment, mitigation, adaptation and integration (conceptual and instrumental). Likewise, all products have followed the integration scheme, verifying the validity of use in both directions, either bottom-up (upscaling the data, if available, from local to continental scales) or top-down (downscaling the data from continental to regional scales).

D5.12 contributes to the following objectives of the project:

- **Objective 1:** to develop, test and disseminate an integrated and science-based strategy for wildfire risk management in Europe.
- **Objective 17:** to expand the EU-wide community of stakeholders involved in wildfire management. The associated **KPI, required the creation of a database with new players** (Annex A: Stakeholder networks).

D5.12 is developed by **WP5** (Activity 5.2.2: Organising and implementing tests) coordinator of the Pilot Site demonstration events of results attained in **WPs 1 to 4**. The key pillars of the demonstrations have been:

- The stakeholders' **needs** and feedback received across the six Pilot Sites' (PS) demonstration events (DE): Kalmar county -SE-, Central Europe transboundary region -DE, PL, CZ-, Central Portugal -PT-, Barcelona province -ES-, Attica region -EL- and the European Territory Region,
- The solutions/**products** developed for wildfire risk assessment, reduction, adaptation, integration and communication, and
- The fitness of those solutions for the purpose of the **IWRM strategy**.

Baseline **reference documents** to this position paper are:

- D4.4 Conceptual framework for integrating risk assessment, reduction and adaptation
- D4.5 Roadmap for an integrated wildfire risk management strategy for Europe
- D4.6 Report on Cascading Effects
- D5.1 User requirements database and report
- D5.2 Portfolio of demonstration products for PS and pan-European demonstrations
- D5.3 Report on the Standardisation of the Demonstration Products and Reporting

Copyright © FirEURisk Consortium. All rights reserved.

- D5.4 Management and action plan for End-users involvement in pilot sites and demonstrations
- D5.6 to D5.11 Reports on specific Pilot Sites Demonstration Events

Dissemination

Early results of this deliverable are published in video format in the project webpage[1] and on YouTube (**835** views on 23/01/2024).
A total of **983** registered stakeholders **participated** in the demonstration events (DE) either in person or online.

Annex A: Stakeholder networks - list the entities that attended to the demonstration events at pilot sites, other than FirEURisk partners **(O17).**

The dissemination objective of this report is two-fold:

- To summarise the keynote results of the project, and
- To list the baseline messages relative to the integrated wildfire risk management strategy across Europe, for policymakers and focus groups.

Objectives not achieved

Not all local-regional products could be upscaled to the whole European territory and be demonstrated accordingly (e.g.: Daily fire danger index or Forest condition biotic damages) (see Annex B: FirEURisk Product Portfolio cross-reference table).

Key take away messages

INTEGRATION FRAMEWORK: The wildfire risk assessment schema consistently handles the following integration components of the fire cycle: danger, exposure, vulnerability, assessment, mitigation, adaptation and integration -conceptual and instrumental-. The FirEURisk project proposes a scalable and adaptable IWRM framework compatible with various geographic scales and stakeholder needs. This framework facilitates multidisciplinary collaboration and accommodates diverse stakeholder interests while aiming to minimise current and future wildfire risks. (Chapter 1).

PILOT SITES AND DEMONSTRATIONS: The demonstration events in the regional pilot sites have proved the coherence and adaptation of the integration scheme to the availability and scale of the data sets (terrain, socio-economic, weather, etc) for wildfire risk management. The adaptation operates bottom-up (local to continental) and top-down (continental to local). (Chapter 2)

PORTFOLIOS OF EUROPEAN, REGIONAL AND LOCAL PRODUCTS SUPPORTING THE INTEGRATED WILDFIRE RISK MANAGEMENT (IWRM) STRATEGY:

The European Core Portfolio: 20 solutions, down scalable at regional scale through the Integrated Fire Risk Index (IRI). (Chapter 3)
The Regional Portfolio: 23 solutions, demonstrated in various PS, capable of reaching European coverage, in the case of available data sources. (Chapter 4)

[1] Spain, Portugal, Central Europe, North Europe, Greece, European Territory.

Copyright © FirEURisk Consortium. All rights reserved.

The local Portfolio: 19 solutions demonstrated in one or various of the 26 local demonstration areas (Chapter 5)

Geospatial layers can be viewed at https://proms.arbonaut.com/newproms while the territorial datasets are accessible through the Data Hub at https://fireurisk.satways.net/datasets (Chapter 6)

POSITIONING MESSAGES:

Key take away messages gathered during the demo events focus on the following themes: wildfire risk assessment (danger, exposure, vulnerability), mitigation and reduction, adaptation, and integration (conceptual and instrumental) (Chapter 7). The most relevant are:



1. Wildfire risk management requires coordinated technical, socio-economic, legal, and political solutions to prevent life and nature destruction.
2. FirEUrisk has developed a comprehensive integration schema for all wildfire phases: prevention, monitoring, preparedness, response, and restoration. Future model evolution looks at integrating fire risks with other non-fire hazards.
3. FirEUrisk has implemented 62 solutions covering the key components of wildfire risk: danger, exposure, vulnerability, mitigation and adaptation strategies, risk assessment and mitigation.
4. Solutions are provided as geospatial, training, methodological, and analytical products in three possible spatial scales: European, regional and local.
5. Fifty-five products have been showcased and validated during demonstration events, engaging 983 stakeholders.
6. Best valued products by stakeholders include Wildland-Urban Interface map, Spring grassland fire model, and Fuel Models.
7. Technical readiness levels (TRL) indicate that 39 products can evolve to prototype stage, and 23 products can be validated and demonstrated.
8. Open access tools are essential for an integrated wildfire risk management system, ensuring universal access to data and models.
9. FirEUrisk offers an integrated wildfire risk management (IWRM) framework for Europe, with an action plan, roadmap, and recommendation for an interagency dedicated to IWRM in the EU.

IMPLEMENTATION LINE:

Three keynote implementation lines remain open for further development:



- The extension of the integration scheme linking fire risks with other non-fire hazards.
- The scientific and technological aspects of wildfires, through the **products** with a **low Technical Readiness Level (TRL)**,
- The **governance** of the wildfire risk cycle, through the implementation of the proposed integrated plan.

Copyright © FirEUrisk Consortium. All rights reserved.

Disclaimer

The content of the publication herein is the sole responsibility of the publishers and it does not necessarily represent the views expressed by the European Commission or its services.

While the information contained in the documents is believed to be accurate, the authors(s) or any other participant in the FirEUrisk consortium make no warranty of any kind with regard to this material including, though not limited to, the implied warranties of merchantability and fitness for a particular purpose.
Neither the FirEurisk Consortium nor any of its members, their officers, employees or agents shall be responsible or liable in negligence or otherwise howsoever in respect of any inaccuracy or omission herein.

Without derogating from the generality of the foregoing neither the FirEurisk Consortium nor any of its members, their officers, employees or agents shall be liable for any direct or indirect or consequential loss or damage caused by or arising from any information advice or inaccuracy or omission herein.

Copyright message

© FirEUrisk Consortium, 2021-2025. This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both. Reproduction is authorised provided the source is acknowledged.

Table of Contents

0. Executive Summary 3
1. The conceptual framework for integrating wildfire risk assessment, reduction and adaptation 18
1.1. FirEUrisk Integration scheme 18
1.2. FirEUrisk integrated wildfire risk management (IWRM) strategy 22
2. Demonstrations and solutions showcased 26
2.1. Lessons learnt from the demonstration events 28
2.2. IWRM solutions demonstrated 32
2.3. Stakeholder engagement network 37
2.4. Technical Readiness Level of Products 41
3. Portfolio of European Core Products for an Integrated Wildfire Risk Management Strategy 45
3.1. Summary of the portfolio 45
3.2. Danger or hazard products 47
3.2.1. Probability of Human Ignition, PHI 47
3.2.2. Probability of Natural Ignition, PNI 49
3.2.3. Live Fuel Moisture Content, LFMC 50
3.2.4. Fuel Classification Map, FCM 51
3.2.5. Fuel Models, FBFM40 52
3.2.6. Canopy Fuel Parameters, CFP 53
3.2.7. Propagation potential indicators for European Territory, PP-ET 55
3.3. Exposure product 57
3.3.1. Exposure, E 57
3.4. Vulnerability products 59
3.4.1. Ecosystem services, ESva 59
3.4.2. Ecological values, EVa 61
3.4.3. Houses value, HV 63
3.4.4. Coping capacity, CC 65
3.4.5. Recovery time, RT 67
3.5. Risk assessment product 69
3.5.1. Integrated fire Risk Index, IRI 69
3.6. Risk mitigation and reduction products 71
3.6.1. Maps of suitable areas for Land Management Strategy 71
3.6.2. Handbook with guidelines to face extreme fires, and fires in Wildland-Urban Interface areas 73
3.6.4. Fire behaviour predictive models 74

Copyright © FirEUrisk Consortium. All rights reserved.

3.7. Risk adaptation product 76
3.7.1. Continental land-use change scenarios and stylised fuel management scenarios 76
3.8. Instrumental products 78
3.8.1. FirEUrisk Open Viewer 78
3.8.2. Laws, regulations, plans and programmes on fire prevention, preparadeness and resilience 79
4. Portfolio of Regional Products for an Integrated Wildfire Risk Management Strategy 80
4.1. Summary of the portfolio 80
4.2. Danger or hazard products 82
4.2.1. Human ignition probability for Pilot Sites 82
4.2.2. Live-fuel moisture content climate archive 84
4.2.3. Fuel Sampling Protocol 85
4.2.4. Fuel type, fuel model, canopy metrics and landscape file 86
4.2.5. Fire danger metric 87
4.2.6. Wildfire spread and behaviour, FlamMap 88
4.2.7. Propagation Potential Indicators for Pilot Sites, PP-PS 90
4.2.8. Smoke potential 91
4.2.9. Fire emission potential 92
4.3. Exposure products 93
4.3.1. Wildland-Urban Interface map 93
4.3.2. Forest fire emission forecast 95
4.3.3. Smoke dispersion forecast 97
4.3.4. Maps of fire exposure metrics 98
4.4. Vulnerability products 99
4.4.1. Relative Societal Vulnerability Index (RESVI) at community level 99
4.4.2. Persistence Index Map 101
4.5. Risk mitigation and reduction products 102
4.5.1. Fuel Management Framework for Reducing Operation-based Ignitions, FuMaF_ROI 102
4.5.2. Land Management Strategies for Adriatic area 105
4.6. Risk adaptation products 106
4.6.1. Future climate information 106
4.6.2. Future fire regime database 107
4.6.3. High resolution future climate information for Greece 109
4.7. Instrumental products 111
4.7.1. Forest condition biotic damages 111

Copyright © FirEUrisk Consortium. All rights reserved.

4.7.2. Program of prescribed burnings 113
4.7.1. Handbook with guidelines to face extreme fires, and fires in Wildland-Urban Interface areas 115
5. Portfolio of Local Products for an Integrated Wildfire Risk Management Strategy 116
5.1. Summary of the portfolio 116
5.2. Danger or hazard product 118
5.2.1. Daily Fire Danger Index, DFDI 118
5.2.2. Fire danger index classification for Chornobyl Exclusion Zone 120
5.2.3. Custom fuel characterization 121
5.2.4. Fuel type and fuel models map 122
5.2.5. Canopy metrics and landscape file 123
5.2.6. Spring grass fire model for the North Europe 124
5.2.7. DSS ChEZ REEFMC 125
5.3. Exposure products 127
5.3.1. WEPPcloud-EU-WATAR 127
5.3.2. Forecast of health-impacts of wildfire-smoke 128
5.3.3. Geospatial integrated eruptive fire risk map and merging fires risk map 128
5.4. Vulnerability products 130
5.4.1. Potential Losses on Ecosystem Services affected by wildfires 130
5.4.2. Suppression Difficulty Index Evaluation 132
5.5. Risk mitigation and reduction products 133
5.5.1. Guidelines for citizens involvement in wildfire risk reduction 133
5.5.2. Factors for building survivability in Scandinavia 134
5.6. Adaptation products 135
5.6.1. Fire risk and strength predictions: short-term & long-term 135
5.6.2. Effective adaptation to changed future fire regimes 138
5.7. Instrumental products 140
5.7.1. Analysis of potential socio-economic barriers, constrains and enables of Land Management Strategies uptake to reduce fire risk 140
5.7.2. Citizens/scientist network and Engagement Plan 141
5.7.3. Guidelines for on-site surveys and subsequent data processing 143
6. Open Access Tools and other integration resources 144
6.1. FirEUrisk Open Platform 144
6.2. Other integration resources 146
6.2.1. FirEUrisk Mobile App 146

Copyright © FirEUrisk Consortium. All rights reserved.

6.2.2. FirEUrisk website 147
6.3. Future implementations within existing fire risk platforms 148
7. Conclusions and position statements 150
8. References 152
9. Annex A: Stakeholder networks 158
10. Annex B: FirEUrisk Product Portfolio cross-reference table 178

Copyright © FirEUrisk Consortium. All rights reserved.

List of Figures

Figure 1. Graphic summary of D5.12 contents. 3
Figure 2. Structure of the FirEURisk Integrated Wildfire Risk Management Strategy framework 4
Figure 3. FirEURisk product portfolios 5
Figure 4. FirEURisk Conceptual integration of wildfire risk assessment components within the FirEURisk project. 18
Figure 5. FirEURisk Integrated Wildfire Risk Management (IWRM) components. 23
Figure 6. Location of local Demonstration Areas (yellow), regional Pilot Sites and European territory (pink) 26
Figure 7. Scaling criteria followed to demonstrate the integration capability of FirEURisk products at PS and ET. 27
Figure 8. Overview of FirEURisk events 38
Figure 9. FirEURisk network by stakeholder categories 38
Figure 10. Overview of attendants by countries. 39
Figure 11. Number of products per TRL. Percentage over total (62 products) 43
Figure 12. FirEURisk European Core Products schema. 45
Figure 13. FirEURisk Regional Products schema. 80
Figure 14. FirEURisk Local Products schema. 116
Figure 15. FirEURisk Open Platform schema. 144
Figure 16. FirEURisk DataHUB Data Repository main page 145
Figure 17. FirEURisk Viewer 145
Figure 18. FirEURisk WIKI main page 146
Figure 19. FirEURisk Mobile App. 147

List of tables

Table 1: List of Acronyms 15
Table 2: Input parameters for FirEURisk Integrated Risk Index, IRI 19
Table 3. Ranking of products validated during the demonstration events at Pilot Sites. 33
Table 4. Products displayed and validated in FirEURisk Demonstration Events. 35
Table 5: Number of attendants by countries and regions 39
Table 6. FirEURisk Products Technical Readiness Level (TRL) at the end of the project 41
Table 7. Pros and Cons of the different TRLs in the FirEURisk European Core Products Portfolio 44
Table 8. FirEURisk European Core Products Portfolio 46
Table 9. FirEURisk Regional Products Portfolio 81
Table 10. FirEURisk Local Products Portfolio 117
Table 11. Stakeholder networks list created in demonstration events, webinars, and project events 158

Copyright © FirEURisk Consortium. All rights reserved.

Copyright © FirEUrisk Consortium. All rights reserved.

List of Acronyms

Table 1: List of Acronyms

List of Acronyms	
ALS	Airborne Laser Scanning
AOI	Area Of Interest
API	Application Programming Interface
AUC	Area Under the Curve
BFB	Basic Fire Behaviour
BROT	Database of plant functional traits for the Mediterranean Basin flora
CAMS	Copernicus Atmosphere Monitoring Service
CBD	Canopy Bulk Density
CBH	Canopy Base Height
CC	Canopy Cover
CDO	Chief Data Officer
CFA	Crown Fire Activity
CFB	Crown Fraction Burned
CFL	Canopy Fuel Load
CFP	Canopy Fuel Parameters
CFW	Canopy Fuel Weight
CH	Canopy Height
ChEZ	Chornobyl Exclusion Zone
CHIMERE	Open-source, multi-scale chemistry-transport model designed for air quality forecasting
CHM	Canopy Height Metrics
CIENSIN	Center for International Earth Science Information Network
CNR	Consiglio Nazionale delle Ricerche (National Research Council, Italy)
DE	Demonstration Event
DFDI	Daily Fire Danger Index
DFHI	Daily Fire Hazard Index
DGECHO	The European Commission's Civil Protection and Humanitarian Aid Operations department
DGVM	Dynamic Global Vegetation Model
DMC	Dry Matter Content
DRMKC	Disaster Risk Management Knowledge Centre
DSS	Dneprospetsstal (Ukrainian manufacturer of special stainless steel)
EFB	Extreme Fire Behaviour
EFFIS	European Forest Fire Information System
EFI	European Forest Institute
EGU	European Geosciences Union
EPSG	European Petroleum Survey Group
ET	European Territory
ESA	European Space Agency
ESV	Ecosystem Service Values
EUT	European Territory
EVA	Ecological Values
EWT	Equivalent Water Thickness
FAI	Forest-Agricultural Interface
FAO	Food and Agriculture Organization
FBFM	Fire Behaviour Fuel Models
FCC	Forest Canopy Cover

Copyright © FirEUrisk Consortium. All rights reserved.

FCCS	Fuel Characteristic Classification System
FCM	Fuzzy cognitive map
FESB	Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, University of Split
FFM	Fire Forecasting Model
FI	Fireline Intensity
FIL	Fire Intensity Level
FL	Flame Length
FPI	Fire Potential Index
FRLMS	Fuel-relevant land management strategy
FRP	Fire Radiative Power
FUI	Forest-Urban Interface
FWI	Fire Weather Index
GDP	Gross Domestic Product
GEDI	Global Ecosystems Dynamics Investigation
GEE	Google Earth Engine
GFC	Global Forest Cover (JRC product)
GFZ	In German, *GeoForschungsZentrum (Geo-research Centre)*
GIS	Geographic Information System
GLAS	Geoscience Laser Altimeter System
GLM	Generalised Linear Model
GLOBIO	Global Biodiversity Model for Policy Support
GLOBIOM	Global Biosphere Management Model
GMV	Grupo Mecánica del Vuelo
GR	Growth Rate
HILDA	Historical Land Use Data
HLFM	Holistic Landscape Fire Management
HMAX	Maximum height
HNMS	Hellenic National Meteorological Service
ICESAT	Ice, Cloud, and land Elevation Satellite
IEEE	Institute of Electrical and Electronics Engineers
IFS	Integrated Forecasting System
IGARSS	IEEE International Geoscience and Remote Sensing Symposium
IRI	Integrated Fire Risk Index
ISS	International Space Station
IWFRM	Integrated Wildfire Risk Management
IWM	Integrated Wildfire Management
IWRM	Integrated Wildfire Risk Management
IWRMS	Integrated Wildfire Risk Management Strategy
KPI	Key Performance Indicator
LBP	Landscape Burn Probability
LEV	Loss of Ecological Values
LFGF	Landscape Fire Governance Framework
LFMC	Live Fuel Moisture Content
LMS	Land Management Strategies
LSCE	Laboratory for Climate and Environmental Sciences
LUT	Look-Up Table
MAE	Mean Absolute Error
MGO	Main Geophysical Observatory
MLR	Multivariate Linear Regression
MODIS	Moderate Resolution Imaging Spectroradiometer

Copyright © FirEUrisk Consortium. All rights reserved.

MSI	Multi-Spectral Instrument
MTT	Minimum Travel Time Fire Spread
NDVI	Normalized Difference Vegetation Index
NGO	Non-Government Organisation
NOAA	National Oceanic and Atmospheric Administration
NUTS	Nomenclature of Territorial Units for Statistics
NVC	Net Value Change
OLI	Operational Land Imager
PALSAR	Phased Array L-band Synthetic Aperture Radar
PBD	Prescribed Burn Days
PCA	Principal Components Analyses
PHI	Probability of Human Ignition
PNI	Probability of Natural Ignition
RESVI	Relative Societal Vulnerability Index
RGR	Relative Growth Rate
RMSE	Root Mean Square Error
ROI	Reducing Operation-based Ignitions
ROS	Rate of Spread
RST	Recovery Starting Time
RT	Recovery Time
RTM	Radiative Transfer Model
SAR	Synthetic Aperture Radar
SDI	Suppression Difficulty Index
SEVEIF	System for the Economic Evaluation of Forest Fires
SRTM	Shuttle Radar Topography Mission
SSH	Secure Shell
SSP	Shared Socioeconomic Pathways
THMAX	Maximum Tree Height
TIFF	Tag Image File Format
TRL	Technology Readiness Levels
UDFHI	Ukrainian Daily Fire Hazard Index
USA	United States of America
USD	United States Dollar
USDA	United States Department of Agriculture
UVSQ	Université de Versailles-Paris-Saclay
VIIRS	Visible Infrared Imaging Radiometer Suite
VPD	Vapor Phase Decomposition
WAI	Wildland-Agricultural Interface
WATAR	Wildfire Ash Transport And Risk
WDTA	Wildfire Danger by Thermal Anomaly
WFI	Wildland-Forest Interface
WGI	Wildland-Grassland Interface
WMS	Web Map Service
WRF-ARW	Advanced Research WRF (Weather Research and Forecasting)
WRM	Wildfire Risk Management
WSF	World Settlement Footprint
WUI	Wildland Urban Interface

Copyright © FirEUrisk Consortium. All rights reserved.

1. The conceptual framework for integrating wildfire risk assessment, reduction and adaptation

1.1. FirEURisk Integration scheme

FirEURisk project is grounded on a sound scientific wildfire risk integration scheme [1], depicted in Figure 4 below. This conceptual frame constitutes a cornerstone output of the project for the wildfire risk prevention community. The three key components to assess wildfire risk are danger, exposure, and vulnerability.

Danger includes:

- Potential of natural or human ignition
- Propagation potential (considering wind, topography, and fuel conditions)

Exposure considers:

- Location of human assets potentially affected by fire, with a focus on WUI
- Ecosystems

Vulnerability includes:

- Estimation of potential losses caused by fire, including:
  - Human assets potentially affected by fire, with a focus on houses and property values
  - Ecosystem services
  - Ecological values
- Resilience, estimated as the reduction of pre-fire values, which increases when:
  - Resistance of resources (coping capacity) is lower
  - Recovery time to reach pre-fire values is longer

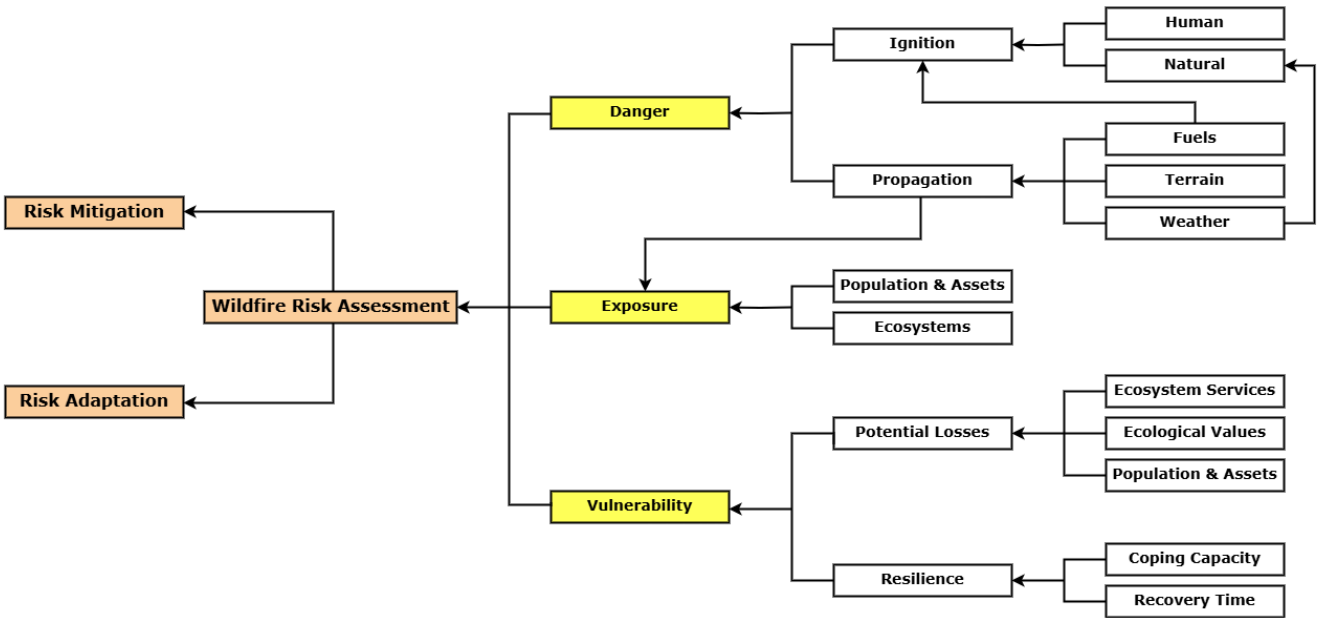


Figure 4. FirEURisk Conceptual integration of wildfire risk assessment components within the FirEURisk project.

Copyright © FirEURisk Consortium. All rights reserved.

Assessing wildfire **risk alone is insufficient**; it must be linked to strategies aimed at mitigating the detrimental impacts of fires on both communities and the environment, whilst preparing for future risk scenarios. Effective wildfire risk management involves evaluating the probability and severity of fire impacts, followed by the development of appropriate measures to reduce the likelihood of fire ignition or to minimise the exposure and vulnerability of people, property and the environment.

Thus, the FirEUrisk integrated **risk framework combines** danger, exposure and vulnerability factors as structured above.

As a result, the conceptual frame has yielded the **Integrated Risk Index (IRI)**, generated for the whole European territory, combining danger, exposure and vulnerability parameters (Table 2):

Table 2: Input parameters for FirEUrisk Integrated Risk Index, IRI

Variable	Units	Sources
TP, Temperature	C	ERA5-Land global reanalysis data
Cl, Cloud cover	%	ERA5-Land global reanalysis data
WS, Wind speed	m/s	ERA5-Land global reanalysis data
RH, Relative Humidity	%	ERA5-Land global reanalysis data
FT, Fuel types	Fuel classes	Satellite data and biophysical models
PI, Potential of Ignition	0/1000	Random Forest model
LFMC, Live fuel moisture content	% Dry Weight	Satellite data
E, Exposure	0, 0.8, 1	WUI and fuel map
VH, Value of Houses	€/ha	European Statistics
ESV, Ecosystem service values	€/ha/year	European Statistics
EVA, Ecological values	0/1000	Cartographic & vegetation databases
CC, Coping capacity	0/1000	Plant functional traits, forest maps
RT, Regeneration time	years	Plant functional traits, forest maps

Given that this **wildfire risk scheme is scale-independent**, the FirEUrisk project implemented it at two distinct spatial scales: regional **pilot sites**, encompassing areas from 2,000 to 8,000 km², handled a high spatial resolution (1 hectare), and the European territory (ET), covering 4.6 million km², generated all datasets at a 1 km² resolution. Each risk variable was mapped at the target spatial resolution of the simulation study, thereby creating a spatially explicit system to estimate fire risk conditions.

Changes in climate trends and society need adaptation policies to counteract the adverse effects of evolving fire patterns. This is particularly pertinent for regions historically less affected by wildfires, which are inherently more vulnerable. Adaptation refers to the process of adjusting to anticipated climatic and societal shifts to better equip society to mitigate negative impacts and potentially benefit from any positive developments.

A range of **factors** contribute to the **heightened risk** of wildfires. Chief among these is the rising frequency of droughts and heatwaves. Additionally, the abandonment of agricultural land, especially in southern Europe, has resulted in landscapes with denser and more contiguous vegetation, which can exacerbate fire behaviour. The expansion of human settlements into fire-prone areas, commonly referred to as the Wildland-Urban Interface (WUI), is another critical

Copyright © FirEUrisk Consortium. All rights reserved.

concern due to the increased potential for loss of life and economic damage. Moreover, limited human and economic resources are usually allocated to land and fire management.

There is a prevailing perception of fire as inherently negative, which frequently emphasises “total suppression”. However, there is an emerging **recognition of the 'fire paradox'**, i.e.: the idea that, in some fire-adapted ecosystems, excluding fire can result in larger and more severe wildfires. This underscores the necessity for the **managed use of fire** as a means of mitigating its harmful effects. Nevertheless, prescribed burns present challenges, particularly in proximity to populated areas or due to concerns over air quality.

Consequently, **FirEURisk concept framework advocates for a broad spectrum of mitigation and adaptation strategies,** tailored to social and ecological conditions, as well as economic and social feasibility. Prioritising actions in the most at-risk areas and determining effective management strategies require a thorough understanding of wildfire risk and its components, well-defined management objectives, and a coherent framework for identifying priorities.
Risk reduction and adaptation strategies can **vary** significantly in terms of their objectives, methods, and geographical scope, depending on legal frameworks, socioeconomic conditions, and local constraints. Implementing wildfire prevention programmes necessitates not only an **understanding of which actions to take but also an awareness of the risks that persist after mitigation and the potential consequences of inaction**. Numerous recent studies have explored the spatial and temporal dimensions of these strategies, including their limitations and effectiveness. Many of these studies utilise **modelling techniques to quantify wildfire danger, exposure**, and associated **uncertainties**.

Establishing **priorities for long-term adaptation** measures is often complicated by differing interests and viewpoints. As such it is necessary and often insightful to involve local communities in the development and implementation of such measures. This is of particular importance in the wildland urban interface, where understanding the perceptions of risk are key to reducing it.
In this context, **scenario-based approaches** have been proposed **to address wildfire risk** by examining various influencing factors, such as climate, socioeconomic trends, and land-use changes, with the aim of fostering landscape-level fire resilience. Certain studies investigate the potential of **landscape-scale land management strategies**, including prescribed burning, silvo-pastoralism, and mechanical fuel removal. However, the uncertainty surrounding many risk drivers and social variables complicates the selection and implementation of these strategies. Furthermore, climate change may constrain opportunities for prescribed burns in certain regions.
Many adaptation studies have focused on local ecological impacts or reducing vulnerability within the WUI. Common strategies in this context include maintaining ecological functions, alleviating biological stressors, creating refugia and corridors, and promoting landscape connectivity.

A final aspect considered in the conceptual framework has been **the dynamic nature of processes** such as urbanisation and forest conversion, which can generate tensions between fire risk planning and the delivery of essential ecosystem services. Adapting to future wildfire risks will require integrating anticipated patterns of land cover and use, socioeconomic trends, and trade-offs for ecosystem services, alongside diverse stakeholder perspectives, to design more fire-resilient landscapes.
In short, FirEURisk has developed **an integrated scheme that considers fire danger, exposure, and vulnerability**.
Key outputs relative to the integrated wildfire risk **assessment** include:

Copyright © FirEURisk Consortium. All rights reserved.

- An assessment system that uses inputs such as weather data, fuel types, topography, ignitions (human and natural), exposure, values of houses and ecosystem services, ecological values, and resilience (coping capacity and recovery time).
- **Geospatial products and models**, that include ignition and propagation potential, danger, expected reduction of values, vulnerability, and an integrated index.
- The implementation of the outputs at two spatial scales: pilot sites (2,000-8,000 km²) plotted at high resolution and the European Territory (ET, >4.6 Mkm²) at 1 km² resolution.
- The possibility of running the assessment under different weather scenarios (extreme, high-risk, and near-real-time daily conditions).
- A computer code to calculate the different components operationally, linking daily/weekly changing variables with static variables.

Key outputs relative to the strategies for wildfire **risk reduction** include:

- **Strategies**, focused on **mitigating** human ignitions and vulnerability across the European territory, with specific measures integrated at pilot site or demo area scales.
- **Guidelines** to **reduce** citizen-driven and operations-based **fire ignitions**, including fuel management along infrastructure corridors (integrated in Attica, Greece).
- Controlled **fires in agro-pastoral areas were demonstrated in Sardinia (Italy) and the French Alps, and adapted to local circumstances following stakeholder involvement**
- Three fuel management strategies have been modelled for risk reduction: herbivory, prescribed burns, and mechanical removal, with suitability models based on existing spatial datasets. This model is used in combination with climate models for adaptation.
- Models have been developed to predict and map smoke releases and extreme fire behaviour, integrated on past fires in Portugal, Spain, Greece, and the Chernobyl region of Ukraine.
- These modelling tools are included in a general handbook with guidelines for fire responders across Europe, addressing extreme fires, WUI fires, and fires at high latitudes/altitudes.
- Dedicated guidelines to reduce communities' vulnerability in the WUI (D2.8).
- Participatory research methods (focus groups, questionnaires) were used to understand local population perceptions in Sardinia, Portugal, Spain, and Greece.

Key outputs relative to the strategies for wildfire **adaptation** include:

- Fire-enabled Dynamic Global Vegetation Models (DGVMs) to **simulate** vegetation and fire patterns under future climate and land use scenarios.
- Realistic future **land use scenarios**, which ingest variables like afforestation, fragmentation, and abandonment, based on IPCC's Shared Socioeconomic Pathways (SSPs) adapted for European climate (**SSP1** "Sustainability" and **SSP3** "Regional rivalry").
- The CLUMondo model to allocate **land use changes (2020-2050)** across the landscape based on demands, spatial characteristics, and climate scenarios.

Copyright © FirEURisk Consortium. All rights reserved.

- The combined use of (i) DGVMs, (ii) CLUMondo's land use results and (iii) historical land use data (HILDA+) has provided **long-term land use scenarios** for Europe at a 9km x 9km resolution; results were harmonized to 9x9 km for DGVMs.
- **Fuel management scenarios** were created to explore managing future fire risk using land management strategies, linked to CLUMondo and DGVM outputs.

1.2. FirEUrisk integrated wildfire risk management (IWRM) strategy

Europe's variety of ecoregions with specific climatic conditions, forest species and fuel composition, management history, natural fire regimes or land management, governance, etc., may make a unique IWRM strategy across Europe seem somewhat, pretentious and beyond logic.
However, to address this challenge, FirEUrisk was engaged to develop a "Conceptual framework for integrating risk assessment, reduction and adaptation", to be tested and applied at local, regional, national and/or EU levels.
The result of this Integrated Wildfire Risk Management (IWRM) is a comprehensive approach which requires collaboration with numerous actors, experts, and stakeholders across the wildfires realm. The goal of defining a common risk management strategy was to present a thorough overview of existing wildfire risk management (WRM) frameworks globally, derived from extensive literature reviews and stakeholder engagement.
The approach includes:

1. **Risk Assessment**: Evaluating wildfire risk factors like danger, exposure, and vulnerability.
2. **Risk Reduction**: Implementing strategies to mitigate identified risks using empirical data and predictive modelling.
3. **Risk Adaptation**: Developing measures to prepare communities and ecosystems for future wildfire patterns considering climate change and land-use changes.

The project distinguishes and evolves from Holistic Landscape Fire Management (HLFM) to Integrated Wildfire Management (IWM). HLFM combines wildfire management with broader landscape objectives, recognising the ecological benefits of wildfires and requiring a comprehensive understanding of landscape dynamics. It is based on principles of ecological restoration, fire prevention, management, and community engagement. In contrast, IWM focuses on reducing wildfires' negative impacts through collaboration among landowners, firefighters, policymakers, and the public, integrating risk reduction into land-use planning.
Likewise, a review of existing frameworks was carried out. All of them have notable approaches, although they do not provide an integrated solution and roadmap. The following are worth mentioning:

- Fire Management Voluntary Guidelines (UN-FAO), 2007
- Wildfires (UN), 2021
- Landscape Fire Governance Framework (UN…), 2023
- DG ECHO Framework for Peer Review (EU), 2023
- USDA National Strategy (USA) 2014, 2022
- Canadian Wildland Fire Strategy (Canada), 2016
- National Bushfire Management Policy (Australia) 2014, 2022
- National Plan for Integrated Rural Fire Management (Portugal), 2018
- Strategic Guidelines for WFM (Spain), 2019.

Copyright © FirEUrisk Consortium. All rights reserved.

FirEUrisk proposes a scalable and adaptable IWRM framework compatible with **various geographic scales** and stakeholder needs. This framework facilitates multidisciplinary collaboration and accommodates diverse stakeholder interests while aiming to minimise current and future wildfire risks. The project ultimately seeks to create a holistic and integrated fire risk management strategy for Europe, encompassing all processes, perspectives, and societal involvement as shown in Figure 5 belowFigure 5. FirEUrisk Integrated Wildfire Risk Management (IWRM) components..

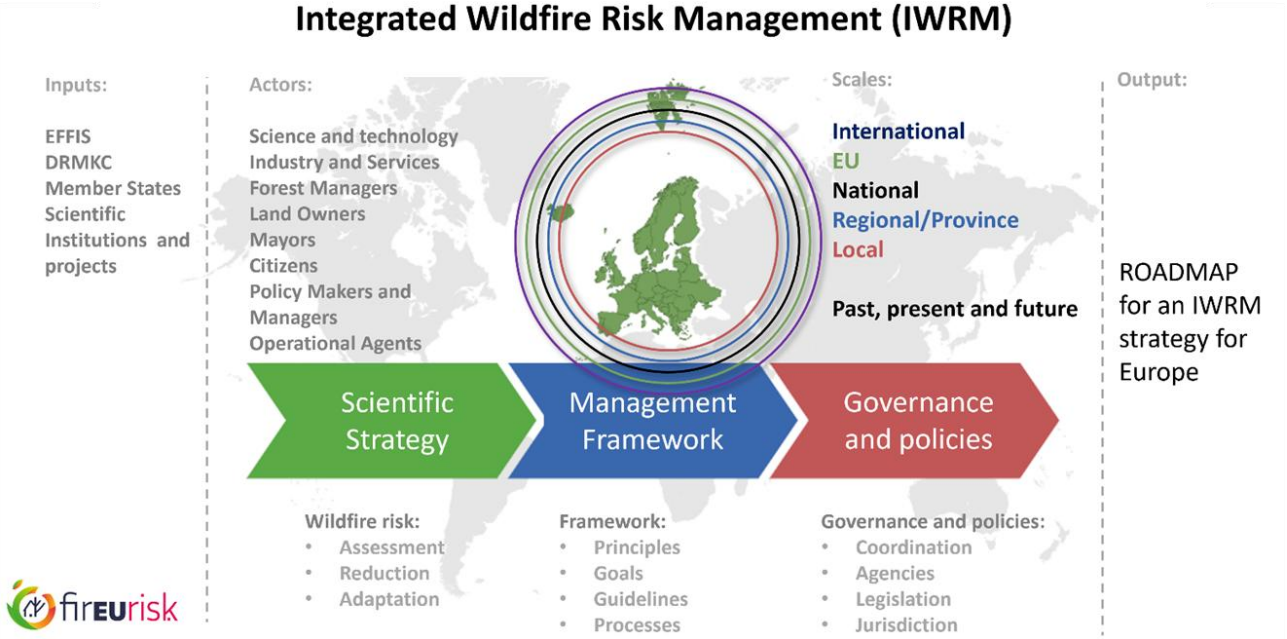


Figure 5. FirEUrisk Integrated Wildfire Risk Management (IWRM) components.

The Integrated Wildfire Risk Management (IWRM) proposed by FirEUrisk targets more resilient rural landscapes and safer communities through four objectives:

- Setting up Integrated Wildfire Risk Management **Governance**
- Procuring the means for an effective Risk **Assessment & Evaluation**
- **Managing** each risk phase: Planning, Preparation, Prevention, Pre-suppression, Suppression, and Post-fire.
- Spanning stakeholder **engagement, particularly in rural areas,** and systemic public **communication**

The proposal considers a number of **cross-sectoral issues** such as the characterisation of the problem in the area, the existence or absence of a strategy, socio-economic and environmental factors, human activities and community involvement, commonalities of agroforestry landscapes like fuel management or specific local issues that may exacerbate the wildfire risk.

The **principles** that guide the IWRM proposal focus on citizens and science, i.e.: protecting human lives and empowering local communities for decision-making processes to enhance wildfire resistance and resilience while planning all activities on sound multi-disciplinary scientific knowledge and updated technological solutions, considering traditional knowledge and existing practices.

The IWRM proposal includes a **management plan,** listing the **key elements** to be accounted for:

- Integrated Wildfire **risk assessment**: hazard identification, exposure and vulnerability

Copyright © FirEUrisk Consortium. All rights reserved.

- Wildfire risk **tolerance**: based on community wildfire culture
- Wildfire risk **management**: risk governance across local public and private sectors
- The Value **Chain**: actions to tackle before, during or after the fire
- **Adaptive** management: to react to uncertainties, evolving conditions, gaps in knowledge and information, etc.
- Stakeholder **engagement**: involves all relevant stakeholders across various target groups.
- **Communication**: to convey the risk perception, understanding of roles and responsibilities among actors
- International **cooperation**: through training, knowledge/data-sharing platforms, etc..
- **Include the governance bodies** at stake: from local to European, with representatives of the following groups: political representatives, forest and civil protection authorities, environmental, security and law enforcing agencies, scientific community, local communities, NGOs and other sectoral policy stakeholders

Effective **wildfire risk management requires coordinated efforts at the local, national, and EU levels,** with clear roles and responsibilities for each actor. A key proposal is the establishment of a European Wildfire Management Directive to harmonize policies on risk assessment, resource allocation, technology, and cross-border coordination.

National governments should align their strategies with this EU directive, integrating climate adaptation and land-use policies. Regional and local authorities are responsible for implementing risk assessments and prevention measures, encouraging community-based approaches and engaging local stakeholders.

Cross-sectoral collaboration is crucial, involving diverse areas beyond forestry and civil protection. EU-wide policies like CAP and Cohesion Policy should be better integrated with wildfire risk management.

The framework emphasises community engagement for building local resilience. Regular communication and coordination mechanisms are needed among all levels to share best practices. **At the EU level**, the European Commission, EFFIS, and the EU Civil Protection Mechanism play coordinating roles. National governments adapt EU directives and coordinate regionally. Local authorities implement strategies on the ground with support. Research institutions provide scientific input.

Adaptive governance is also proposed in FirEUrisk IWRM strategy , meaning that strategies and policies should be flexible and able to adjust to changing conditions, including the impacts of climate change and socio-economic developments. This involves a process of **continuous learning and improvement** based on experience and new knowledge.

Technological innovation plays a crucial role in enhancing wildfire management across all stages. This includes leveraging technologies such as **remote sensing for monitoring and early detection, artificial intelligence (AI) and predictive modelling for risk assessment and forecasting, and advanced communication systems for coordination and public alerts**.

It is essential to **integrate scientific knowledge and research findings** into wildfire management practices and decision-making processes. This should be coupled with the consideration of **local knowledge and traditional practices**, ensuring a holistic and informed approach to managing wildfire risks.

Copyright © FirEUrisk Consortium. All rights reserved.

The proposal established clear performance indicators (KPIs) to monitor the progress and effectiveness of strategies and actions. These indicators should be **measurable, relevant, and aligned with the objectives and goals** of the integrated wildfire risk management system.

Policy instruments play a crucial role in implementing and enforcing wildfire risk management strategies. These can include **regulations, financial incentives, land-use planning policies, and educational programs**. It is important that these instruments are **coherent, coordinated across different levels of governance, and effectively enforced**.

Finally, **data collection and analysis are essential** for informed decision-making and for tracking the impact of implemented measures. This includes collecting data on fire occurrences, impacts, and the effectiveness of different management approaches.

Copyright © FirEUrisk Consortium. All rights reserved.

2. Demonstrations and solutions showcased

This section synthesises some lessons learnt during the demonstration events (DEs) for each pilot site (PS), beyond the items already reported in Deliverables D5.6 to D5.11.

The DEs showcased the results of FirEUrisk in the format of "**products**" which include **geospatial thematic maps, training materials, socio-economic analysis, guidelines, training materials, etc.** Demonstrations took place between 2023 and 2024 in the five regional Pilot Sites and across the whole European Territory, as shown in Figure 6 below.

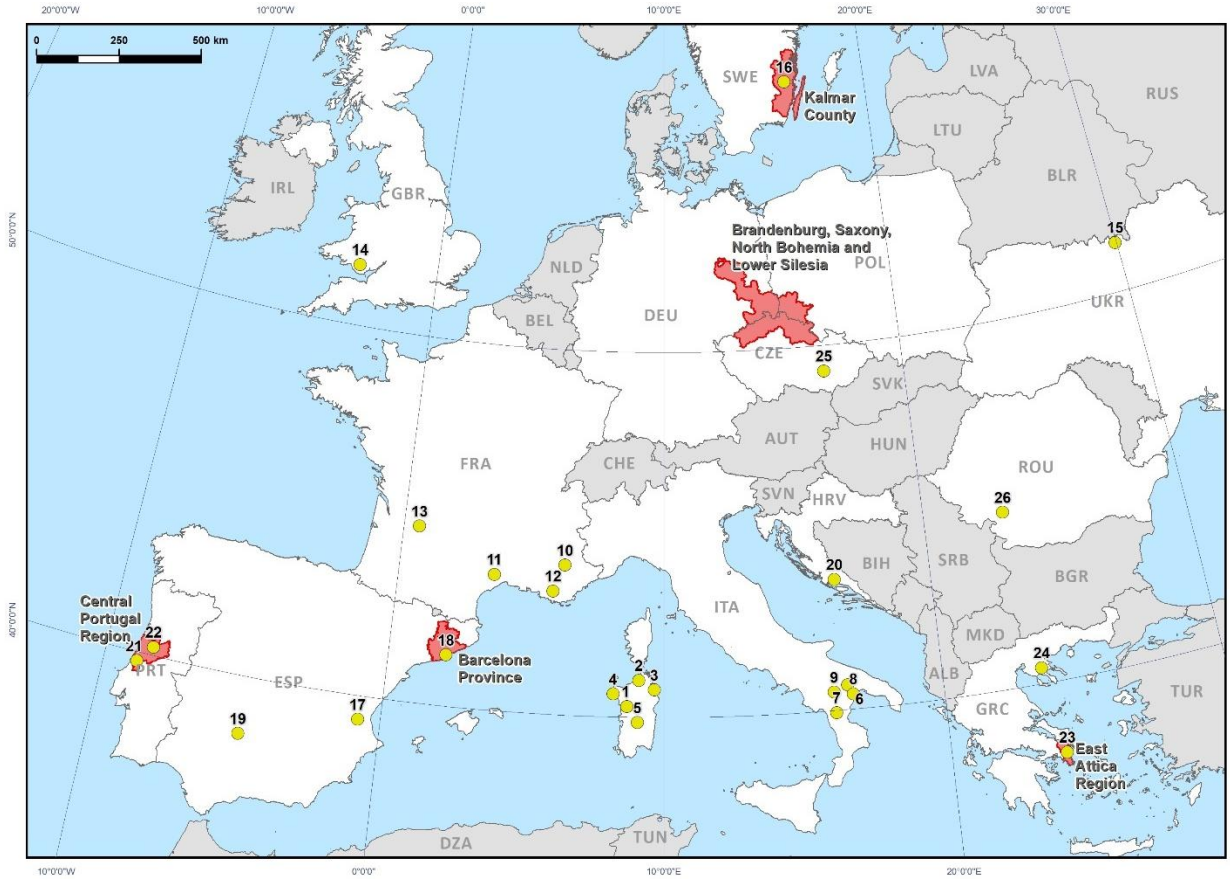


Figure 6. Location of local Demonstration Areas[2] (yellow), regional Pilot Sites and European territory (pink)

The objectives of the demonstration events at the regional Pilot Sites:

1) Targeted PS end-users' **needs** and requirements.

[2] [1] Municipalities of Suni and Sindia (Sardinia, Italy), [2] Municipalities of Tempio and Municipalities of Bonorva and Mores (Sardinia, Italy), [3] Municipalities of San Teodoro and Budoni (Sardinia, Italy), [4] Porto Conte Nature Reserve (Sardinia, Italy), [5] Sardinia, Italy, [6] Municipality of Matera (Basilicata, Italy), [7] Lauria and Pollino (Basilicata, Italy), [8] Metaponto area, Ionia coast (Basilicata, Italy), [9] Basilicata, Italy, [10] Alpes-de-Haute-Provence department (Alps, France), [11] Puechabon study site (Montpellier, France), [12] Rougiers community (Var department, France), [13] Corsica, Provence-Alpes-Côte d'Azur, Occitanie and Nouvelle Aquitaine (France), [14] Rhondda Cynon Taff (South Wales, UK), [15] Chernobyl contaminated area (Ukraine), [16] Kalmar county (Sweden), [17] Province of Valencia (Spain), [18] Collserola (Barcelona, Spain), [19] Sierra Morena of Córdoba (Spain), [20] Coastal side and hinterland of mountain Kozjak (Croatia), [21] Central Region of Portugal, [22] Central Region of Portugal, [23] Mati peninsula Rafina-Pikermi (Greece), [24] Taxiarchis Forest in Chalkidiki (Greece), [25] Křtiny Forest (Brno, Czech Republic), [26] Mehedinți (MH) and Gorj (GJ) counties (Romania).

Copyright © FirEURisk Consortium. All rights reserved.

2) **Demonstrated** the fire risk assessment, reduction, and adaptation **products**.
3) Ensured that demonstration **products** were reachable through WP4 **platform**.
4) Facilitated on-site/on-line **product validation** templates to the attendees so that, at least a preliminary qualitative/quantitative validation of the products was done during the DE.

The spatial scale of the products to be demonstrated was established in D5.3 *Report on the Standardisation of the Demonstration Products and Reporting*, as follows:

- The 26 Local **Demonstration Areas** (e.g. Croatia, Sardinia, France, Ukraine) handled **variable spatial scales**;
- The 5 **Pilot Sites** (Barcelona, Central Portugal, Central Europe, Kalmar County, Attica region) handled products at a standard spatial **scale of 1 ha,** although many products reached better spatial resolutions.
- The **European Territory** geospatial products handled a scale of 1 km^2 and were demonstrated in Milan and during an on-line webinar.

The coordinate reference system of geospatial products is ETRS89/LAEA1052, except for climate datasets georeferenced to WGS84.
The conceptual integration schema (Section 1.) has been **implemented by** the products developed in WPs 1-4 in two manners, as summarised in Figure 7 below:

- Some products followed an upscaling implementation criterion, from **local to regional and to European scales, if data were available**.
- The integration criteria was tested in a downscaling modelling procedure, from data available for the whole ET that could be adapted to the regional pilot sites through the variables of the Integrated Risk Index, IRI (see Table 2 above).

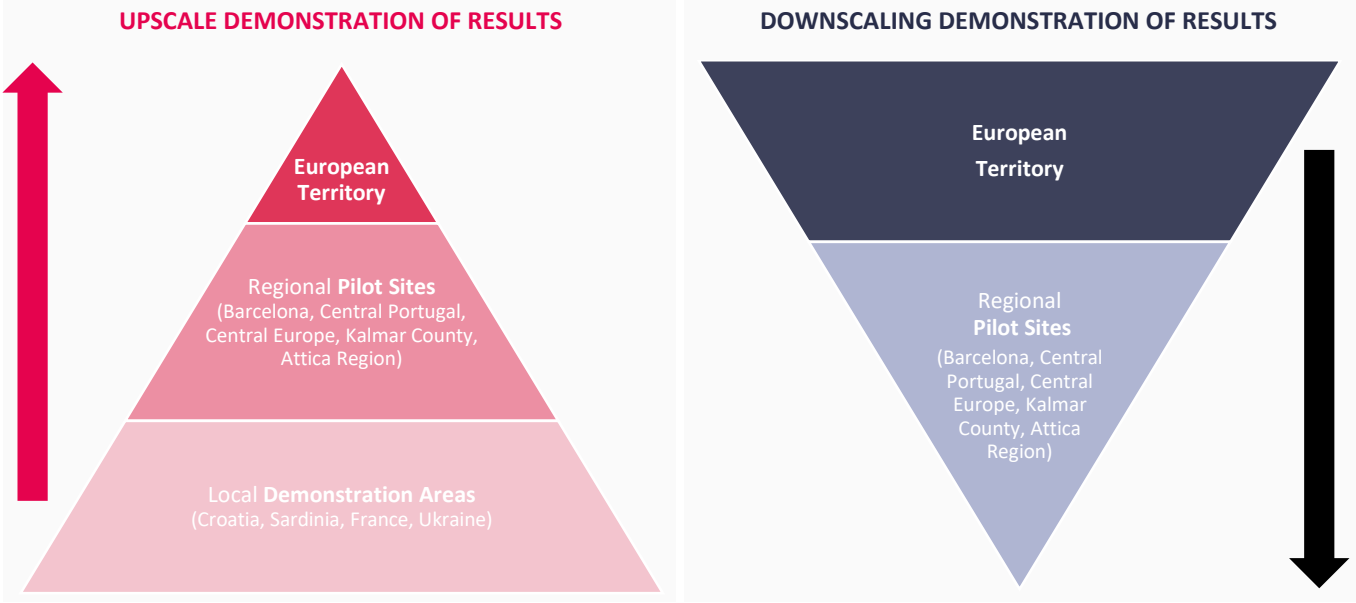


Figure 7. Scaling criteria followed to demonstrate the integration capability of FirEURisk products at PS and ET.

Wildfire risk varies significantly across different territories and time periods. The scalability approach considers risk conditions within various spatial scales to ensure realistic wildfire risk assessment, reduction, and adaptation. **Each**

Copyright © FirEURisk Consortium. All rights reserved.

product follows an integration schema, either bottom-up or top-down, according to its role in an integrated scalability within the IWRM. Some products are applicable only at a local scale, while others are relevant within the broader European context (i.e., continental scale). Some **upscaled products** (i.e., bottom-up territorial scale) are developed from local data and then generalised to larger areas. Examples include natural fire ignitions such as lightning, fire propagation, fuel consumption, and smoke emissions as risk factors, environmental vulnerability and resilience assessment, economic impacts of fire, risk assessment integration, and risk reduction strategies. On the other hand, **downscaled products** (i.e., top-down territorial scale) are derived from broader regional or continental data and then applied to smaller, more specific areas. Examples include the probability of human ignition, probability of natural ignition, live fuel moisture content, fuel classification map and fuel models, canopy fuel parameters, propagation potential indicators for the European territory, exposure, ecosystem services, ecological values, house values, coping capacity, recovery time, integrated fire risk index, maps of suitability of fuel-relevant LMS in Europe, and continental land-use change scenarios and stylized fuel management scenarios.

2.1. Lessons learnt from the demonstration events

FirEURisk conducted several pilot site demonstration events across Europe[3], each providing valuable insights into the operability, usability, and effectiveness of fire risk management. These six events demonstrated the applicability and use of product portfolios, European and Regional, in different scenarios of Europe that have particular problems of wildfire risk.

The **first demonstration event,** carried out in **Barcelona**, Spain, focused on the **WUI**, forest and fuel management, and resilient landscapes. It was organised by the University of Lleida (UdL), in collaboration with the Provincial Deputation of Barcelona; this event presented the wildfire prevention resources tested under Mediterranean fire risk conditions. The products converged in **optimizing** forest and **fuel management** within a resilient landscape paradigm around Barcelona urban area, addressing the high **vulnerability** of dense, homogeneous forests to wildfires due to agricultural abandonment and lack of management. The province of Barcelona experiences frequent large fires, exacerbated by heat waves and droughts, leading to the implementation of professionalised fire-prevention silviculture, though budget constraints and fragmented governance responsibilities pose challenges. Experts shared research outcomes related to weather and ignitions, fuels, propagation, population and assets, exposure, potential losses, resilience, risk reduction, and end-user needs. The agenda included presentations on metrics capturing dead fuel moisture and atmospheric instability, live-woody fuel moisture content prediction models, and wildfire ignition likelihood from both lightning and human causes. The event emphasized the importance of presenting the FirEURisk online viewer at the beginning of the session to demonstrate the operability and usability of the products. The thematic geo-information layers were uploaded into the viewer two weeks in advance, allowing for validation questions. Providing a product definition card

[3] •PS1 - North Europe: Kalmar County in Sweden, led by RISE.
•PS2 - Central-Eastern Europe: Southern Brandenburg and Eastern Saxony in Germany, North Bohemia in Czechia, Lower Silesia in Poland. Led by TUD.
•PS3 - Mediterranean (Portugal): Central Region of Portugal, led by ADAI.
•PS4 - Mediterranean (Spain): Collserola Natural Park and Barcelona Province, led by UdL.
•PS5 - Mediterranean (Greece): Attica Region, led by KEMEA.
•EUT - Pan-European scale whose leading institutions are UAH and ADAI.

Copyright © FirEURisk Consortium. All rights reserved.

with technical specifications further helped attendees understand the usability of the products in their regular work. Other **fire risk components noted by attendants** were: fuel management plans, awareness-raising of the risk of fire, awareness, education and training of citizens, land management plans, fuel moisture modelling, fire modelling, firefighter's training, danger prediction and access to the forested lands.

The **second pilot site demonstration event in Coimbra**, Portugal, focused on fire risk assessment, reduction, and adaptation. It brought together over 350 participants, including scientists, local and national authorities, forest landowners, firefighters, civil protection personnel, and other key stakeholders. The session showcased innovative products and solutions developed within the FirEUrisk project and its application to the Coimbra and Leiria Intermunicipal Communities, such as early warning systems, fire and smoke propagation models, fuel maps, and risk assessment products. This Central Region is highly susceptible to wildfires, especially in the eastern mountainous areas and western coastal forest patches. The coastal west has a younger, more educated population with higher infrastructure density, while the inland east has an older demographic focused on agroforestry. Migration to coastal cities has led to abandoned agroforestry areas, increasing wildfire risk, as seen in the catastrophic 2017 fires in Portugal (i.e. Pedrogão Grande fires on June 17th). These geospatial information products support the management of rural fires in various phases and can be adapted to specific regional needs. Stakeholders actively participated by offering suggestions to enhance the tools' effectiveness and applicability. Products focusing on fire risk assessment garnered particular enthusiasm due to their direct applicability to the pilot site area. The scalability of these products and the need for widespread dissemination and training were emphasised, highlighting the importance of continuous evolution and refinement of FirEUrisk products. The event also featured an interactive component where participants provided real-time feedback using an app, allowing for immediate insights into the practicality and usefulness of the presented solutions. Other **fire risk components highlighted by attendants** were fire propagation focused on fuels, terrain and weather; smoke propagation and health; natural and human ignition causes and exposure of population assets

The **third pilot site demonstration event**, held online **from Dresden, Germany**, focused on advancing fire risk assessment, reduction, and adaptation, with an emphasis on transboundary cascading effects and future scenarios. Interest in studying wildfires in Central Europe has grown recently due to several large fires, notably the 2022 fire in Saxon Switzerland (Germany) and Bohemian Switzerland (Czechia). Public discussion continues about wildfire risks in the Wildland Urban Interface, exacerbated by deadwood from severe bark beetle infestations. The demonstration event addressed these risks with products like Wildfire Urban Interface Mapping, Factors for Building Survivability, and Curricula for Extreme Fires and Wildland Urban Interface. This session brought together over 95 participants, including scientists, research institutes, local and national authorities, forestry agencies, national weather services, firefighters, nature protection specialists, and other key stakeholders. Using examples from three Central European countries (Czechia, Germany, and Poland), 15 innovative products and tools were presented. The products were well-received, expressing the need for more detailed information on wildfire risk. **Their key requests included**: improved resolution and localised assessments, enhanced training for practitioners, better understanding of fuels in the WUI, easier access to data, a firefighting index, detailed fuel maps for firefighting -vertical structure, suppression tactics-, increased awareness campaigns, fuel management recommendations, and cross-border wildfire risk assessments. These requests will serve as a basis for the improvement and refinement of the FirEUrisk products and tools.

The **fourth pilot site demonstration event in Sweden** focused on future wildfire risks in Northern Europe. Held online and partly in person from Stockholm, the event addressed the region's long history of fires and the recent resurgence of wildfire hazards due to climate change, land use, and demographic shifts. The event gathered 72 participants from

Copyright © FirEUrisk Consortium. All rights reserved.

14 countries, including civil protection authorities, forestry and agriculture representatives, fire and rescue services, researchers, and meteorologists. The products presented included knowledge summaries, tools for future projections, and map services. End-users evaluated products. Most products were well received, with a strong emphasis on user-friendliness and accessibility. Participants wanted a centralized, user-friendly platform for all necessary information. Previous projects had issues with complex and hard-to-use files. **End-users also highlighted** the need for a strong connection to current landscape management and forestry practices. The civil protection organization stressed the importance of detection and localization for North Europe, noting the lack of such features in the program. They also emphasised the need for models suitable for Scandinavian surface fuels -fast growing spring grasslands-, not those like FlamMap used further south. Both research and rescue organisations highlighted that integrating wildfire risk into a single scalar number isn't crucial. Instead, the focus should be placed on how improvements in one area might negatively impact others, emphasising qualitative over quantitative interactions. Products were well received, especially those showing real outcomes relevant to current issues. User-friendliness was vital, and products aimed at knowledge and awareness should use simple language. There were also discussions on products relating to current forestry practices, despite challenges due to landowner autonomy and complex regulations.

The **fifth pilot site demonstration event in Rafina, Attica**, Greece, addressed fire risk in WUI areas. It was organised by the Laboratory of Forest Management and Remote Sensing at the Aristotle University of Thessaloniki, in collaboration with the Municipality of Rafina-Pikermi. The Attica region is characterised by a heterogeneous landscape comprising dense residential areas, agricultural lands, and extensive pine forests highly susceptible to combustion. WUI areas in Attica are distributed around the densely populated suburbs of Athens, and adjacent to coastal settlements. The region's hot, dry summers with strong winds exacerbate wildfire propagation. These meteorological patterns facilitate rapid fire spread, increasing the vulnerability of the WUI areas. The research focused on developing cartographic and methodological tools for assessing critical situations to support forest fire prevention and preparation at local and regional levels. Products included mapping of forest fuel and WUI zones, methodology for vegetation management around critical infrastructures, seasonal fire risk assessment, climate change impact analysis, and evaluation of socio-economic conditions. Effective fire risk management should focus on controlling fire spread and reducing potential losses. Key strategies include fire prevention, community preparedness, and resilience, while considering ecological and socio-economic impacts. Education programs, risk communication, and community involvement are crucial. Although current tools are effective, they need improvement, especially in predictive models. Adaptation strategies should include long-term fire-weather projections and enhance social adaptation to strengthen community resilience. Real-time data and consistent data-sharing protocols are important for effective fire response. Continuous innovation and stakeholder feedback ensure the tools remain effective. **The main priorities** highlighted by attendants included reducing fire spread and minimising damage, engaging local communities, improving predictive models, and using real-time data for preparedness. Thus, the event emphasised the importance of community involvement and education, with guidelines and policies for reducing anthropogenic fires and managing extreme fire incidents.

Finally, the **European demonstration event** in a hybrid mode, held at the *Consiglio Nazionale delle Ricerche* (CNR) in Milan, Italy, the event was attended by 35 participants in person, including representatives from the EU Joint Research Centre, fire services, and researchers from various European institutions, along with 148 online participants from universities, research centres, fire services, civil protection, NGOs, and private institutions such as insurance companies. The objectives were to present the products developed during the FirEUrisk project at a European scale and to gather

Copyright © FirEUrisk Consortium. All rights reserved.

feedback on the results. The European territory encompasses continental Europe and the Mediterranean islands within its boundaries, excluding Iceland, Cyprus, the Canary Islands, and the Azores. This area includes the Mediterranean countries in the south, temperate regions in Central Europe, and extends to the boreal regions in northern Norway. Experts presented products related to danger components (human and natural sources of ignition, live fuel moisture content, fuel types, fire propagation), vulnerability components (ecological values, coping capacity and recovery time, ecosystem services), fire mitigation and adaptation to climate scenarios, and risk integration and validation. The hybrid format increased attendance and facilitated interaction and feedback, with surveys distributed in separate questionnaires allowing timely feedback after each presentation block.

These lessons highlight the importance of usability, stakeholder engagement, continuous refinement, and effective communication in fire risk management. By integrating these insights, FirEUrisk can enhance its tools and strategies, ultimately contributing to more effective and resilient fire risk management across diverse regions.

Copyright © FirEUrisk Consortium. All rights reserved.

2.2. IWRM solutions demonstrated

During the Demonstration Events, stakeholders (between 42 and 350 attendants) were asked about the **most important aspect of the wildfire risk integration schema** in their activity. Their responses are summarized below:

- In **Mediterranean-Spain**, the most relevant component of wildfire risk assessment was resistance and response capacity (30.6%), followed by fire propagation (27.8%), indicating high concern on how fires spread and the response capacity in Barcelona province.
- In **Central-Portugal**, fire propagation was the most important aspect (28.7%), followed by population and assets exposure (22.9%). Thus, in Central Portugal the emphasis was placed on the dynamics of fire spread and the protection of human lives and property.
- **Central Europe** showed similar interests to those in Portugal, focusing on fire propagation (31.5%) and natural and human ignition causes (20.4%); aspects related to danger or hazard were the most popular across local experts.
- In **Northern Europe**, fire propagation, fuels, terrain and/or weather, emerged as the most important aspect for integration (30.2%) while population and assets exposure also scored a significant concern (20.9%).
- In **Mediterranean-Greece**, responses pointed at fire propagation and potential losses (22.9%), population and assets exposure and ignition cause (20% each). Hence, Attica Region equally demands solutions in the three fire risk components: danger, exposure and vulnerability.

Fire propagation (danger/hazard) is the most critical aspect across all regions, reflecting a widespread concern for understanding and managing the factors that influence the spread of wildfires. Other aspects, such as **resistance and response capacity** (vulnerability), and **population and assets exposure**, also play crucial roles, highlighting the multifaceted nature of wildfire risk assessment and the need for comprehensive strategies to address these challenges.

The validation of the **Regional Products Portfolio** was conducted through live surveys during demonstration events at Pilot Sites. Products were assessed based on several key aspects: product explanation, regional suitability, approach, usability, and interest. In terms of approach, the innovative methodologies and frameworks presented were well-received, particularly by academic and policy-making participants, who appreciated the evidence-based and systematic nature of the solutions. Usability was another critical factor, with first responders and land managers highlighting the practical and user-friendly design of the products. Lastly, the level of interest varied among the target audiences, with landowners and managers showing the most enthusiasm, likely due to the direct applicability of the products to their daily operations. During demonstrations, stakeholders validated the products, ranking them as shown in Table 3.

Copyright © FirEUrisk Consortium. All rights reserved.

Table 3. Ranking of products validated during the demonstration events at Pilot Sites.

Rank	PS4 - Barcelona Province	PS3 - Central Portugal	PS2 - Central Europe	PS1 - North Europe	PS5 - Attica Region
1st	Wildland-Urban Interface map	Wildland-Urban Interface map	Wildland-Urban Interface map	Spring grassland fire model	Fuel Models, FBFM40
2nd	Fuel type, fuel model, canopy metrics, and landscape file	Fuel Models, FBFM40	Spring grassland fire model	Forest fire emission forecast	Wildland-Urban Interface map
3rd	Wildfire spread and behaviour, FlamMap	Fuel Management Framework for Reducing Operation-based Ignitions, FuMaF_ROI	Forest condition biotic damages map	Future fire regimes database	Guidelines to reduce communities' vulnerability to extreme fires and fires in Wildland-Urban Interface
4th	Custom fuel characterization	Human ignition probability for Pilot Sites	Wildfire spread and behaviour, FlamMap	Wildland-Urban Interface map	Fuel Management Framework for Reducing Operation-based Ignitions, FuMaF_ROI
5th	Natural ignition probability for Pilot Sites	Citizens scientist network and Engagement Plan	Factors for building survivability	Factors for building survivability	Citizen's scientist network and Engagement Plan
6th	Relative Societal Vulnerability Index (RESVI) at community level	Fire behaviour predictive models	Satellite-Derived Live Fuel Moisture Content	Continental land-use change scenarios and stylised fuel management scenarios	Curricula for extreme fires and Wildland Urban Interface
7th	Suppression Difficulty Index Evaluation	Smoke dispersion forecast	Future fire regimes database		High resolution future climate information for Greece
8th	Persistence Index Map	Maps of suitable areas for Land Management Strategy	Curricula for extreme fires and Wildland Urban Interface		Effective adaptation to changed future fire regimes
9th	Human ignition probability for Pilot Sites	Relative Societal Vulnerability Index (RESVI) at community level	Propagation potential indicators for Pilot Sites, PP-PS		Future fire regimes database
10th	Smoke potential	Continental land-use change scenarios and stylised fuel management scenarios	Daily Fire Danger Index, DFDI		Fire behaviour predictive models
11th	Weekly fire danger metric at 25 ha		Human ignition probability for Pilot Sites		Smoke dispersion forecast
12th	Weekly live fuel moisture content at 25ha		Suppression Difficulty Index Evaluation		Forest fire emission forecast
13th			Potential Losses on Ecosystem Services affected by wildfires		
14th			Fire danger metric		

Table 3 above reveals the validated products that received the highest scores:

- The **Wildland-Urban Interface map** was highly ranked in Barcelona Province, Central Portugal, and Central Europe, highlighting its importance in fire management and prevention strategies.
- The **Fuel Models, FBFM40** were top-rated in the Attica Region and second in Central Portugal, emphasizing their role in understanding fuel types and behavior during fires.
- The **Spring grassland fire model** was valued in North Europe and Central Europe, providing crucial predictions for early fire detection and response in grassland areas.
- The **Fuel type, fuel model, canopy metrics, and landscape file** scored second in Barcelona Province, offering comprehensive data for accurate fire risk assessments.

Copyright © FirEURisk Consortium. All rights reserved.

- The **Forest fire emission forecast** was second in North Europe, important for understanding the environmental impact of forest fires.
- The **Forest condition biotic damages map** was third in Central Europe, highlighting areas affected by biotic damage that influence fire behaviour.
- The **Fuel Management Framework for Reducing Operation-based Ignitions, FuMaF_ROI** was third in Central Portugal, providing strategies to minimise ignitions from operational activities.
- The **Wildfire spread and behavior, FlamMap** was third in Barcelona Province, offering simulations crucial for effective fire response planning.
- The **Future fire regimes database** was third in North Europe, helping prepare for long-term fire management challenges.

In the **European Territory Demonstration Event**, several objective questions were posed to assess the agreement with the methods used to generate the products for IWRM solutions. Given that most participants were specialists in the fire phenomenon, either as researchers or fire practitioners, this high level of agreement indicates that the methods used to generate the products are well accepted by the fire community. On average, **83.7% of all responses were either 'Mostly agree' or 'Completely agree'**. The comments received for specific questions mainly focused on suggestions for improving the products in future research by considering additional parameters. Also, they highlighted the limited applicability of certain products for specific applications and stressed the complexity of the phenomena being studied, which makes it challenging to address all components comprehensively.

Regarding the methods for integrating fire danger, most responses agreed with the method proposed by the European Core Products Portfolio. While 66% of responses agreed with FirEUrisk's mathematical method of integration, the remaining 34% who selected other options indicated a lack of consensus on the best mathematical formula for integration. With respect to the framework for fire risk estimation, most responses (91%) agreed on the **importance of all components used** (danger, exposure, and vulnerability). Only two responses discarded the use of the exposure component. Thereby, the responses reflected a thorough agreement with the approaches and methods proposed:

- For Probability of Human Ignition, 73.3% agreement.
- For Probability of Natural Ignition, 80.2%.
- Live Fuel Moisture Content, 90.5%.
- Fuel Classification map, Canopy Fuel Parameters, and Fuel Models (FBFM40), 84.2%.
- Propagation Potential Indicator, 88.1%.
- Ecological Values (85.11%) and Coping Capacity/Recovery Time (82.6%.)
- Ecosystem Services (86.96%) and Mitigation products (86.4%).

These results **indicate a strong support of FirEUrisk's methods** across various aspects of wildfire risk assessment.

Table 4 below lists all 55 products demonstrated during the FirEUrisk Demonstration Events, indicating the producer and the IWRM components demonstrated.

Copyright © FirEUrisk Consortium. All rights reserved.

Table 4. Products displayed and validated in FirEURisk Demonstration Events.

FirEUrisk Products	Producer	IWRM	PS4 Barcelona Province, SP	PS3 Central Portugal, PT	PS2 Central Europe, CZ-DE-PL	PS1 North Europe, SE	PS5 Attica Region, EL	ET European Territory
Probability of Human Ignition, PHI	UAH	DANGER						x
Human ignition probability for Pilot Sites	UdL	DANGER	x	x	x			
Probability of Natural Ignition, PNI	UAH	DANGER						x
Natural ignition probability for Pilot Sites	UdL	DANGER	x					
Live Fuel Moisture Content, LFMC	UAH	DANGER						x
Weekly live fuel moisture content at 25ha	UdL	DANGER	x					
Satellite-Derived Live Fuel Moisture Content	SIA	DANGER			x			
Fuel classification map	UAH	DANGER						x
Canopy fuel parameters	UAH	DANGER						x
Fuel Models, FBFM40	UAH	DANGER		x			x	x
Custom fuel characterization	UdL	DANGER	x					
Fuel type, fuel model, canopy metrics, and landscape file	UdL	DANGER	x					
Propagation potential indicators for European Territory, PP-ET	UAH	DANGER						x
Propagation potential indicators for Pilot Sites, PP-PS	FESB	DANGER			x			
Fire danger metric	UdL	DANGER			x			
Weekly fire danger metric at 25 ha	UdL	DANGER	x					
Daily Fire Danger Index, DFDI	SIA	DANGER			x			
Wildfire spread and behaviour, FlamMap	UdL	DANGER	x		x			
Spring grassland fire model	RISE	DANGER			x	x		
Forest condition biotic damages	GMV	DANGER			x			
Exposure, E	HU	EXPOSURE						x
Wildland-Urban Interface map	HU	EXPOSURE	x	x	x	x	x	
Population and assets	UdL	EXPOSURE	x					
Forest fire emission forecast	UAVR	EXPOSURE				x		
Smoke potential	UAVR	EXPOSURE	x					
Maps of fire exposure metrics	UAVR	EXPOSURE	x					
Suppression Difficulty Index Evaluation	UCO	EXPOSURE	x		x			
Ecosystem Services, ESva	UAH	VULNERABILITY						x
Potential Losses on ecosystem services affected by wildfires	UCO	VULNERABILITY	x		x			
Ecological values, EVa	UAH	VULNERABILITY						x
Houses value, HV	HUTTON / UAH	VULNERABILITY						x

Copyright © FirEURisk Consortium. All rights reserved.

FirEUrisk Products	Producer	IWRM	PS4 Barcelona Province, SP	PS3 Central Portugal, PT	PS2 Central Europe, CZ-DE-PL	PS1 North Europe, SE	PS5 Attica Region, EL	ET European Territory
Coping capacity, CC	UAH	VULNERABILITY						x
Relative Societal Vulnerability Index (RESVI) at community level	ISIG	VULNERABILITY	x	x				
Persistence Index Map	UdL	VULNERABILITY	x					
Recovery time, RT	UAH	VULNERABILITY						x
Integrated fire Risk Index, IRI	UAH	RISK ASSESSMENT						x
Maps of Suitability of Fuel-Relevant LMS in Europe	VUA	RISK MITIGATION						x
Curricula for extreme fires and Wildland Urban Interface	SAFE	RISK MITIGATION			x		x	
Fire behaviour predictive models	ADAI	RISK MITIGATION		x			x	
Risk reduction and end-user needs	HUTTON	RISK MITIGATION	x					
Fuel Management Framework for Reducing Operation-based Ignitions	AUTH	RISK MITIGATION		x			x	
Maps of suitable areas for Land Management Strategy	VUA	RISK MITIGATION		x				
Forest fire emission forecast	UAVR	RISK MITIGATION		x			x	
Smoke dispersion forecast	UAVR	RISK MITIGATION		x			x	
Guidelines to reduce communities' vulnerability to extreme fires and fires in WUI	METEOGRID	RISK MITIGATION					x	
Citizen's scientist network and Engagement Plan	ISIG	RISK MITIGATION		x			x	
Factors for building survivability	RISE	RISK MITIGATION			x	x		
Continental land-use change scenarios and stylised fuel management scenarios	VUA	RISK ADAPTATION		x		x		x
Future fire regimes database	PIK	RISK ADAPTATION			x	x	x	x
Effective adaptation to changed future fire regimes	PIK	RISK ADAPTATION					x	
High resolution future climate information for Greece	NCSR	RISK ADAPTATION					x	
FirEUrisk Open viewer	ARBONAUT	INSTRUMENTAL	x	x			x	x
Open Platform of models, data and knowledge	SATWAYS	INSTRUMENTAL					x	

Copyright © FirEUrisk Consortium. All rights reserved.

2.3. Stakeholder engagement network

The FirEURisk strategy was **co-designed and developed in close collaboration with researchers, practitioners, policymakers, and citizens**. It encompassed technologies, tools, training materials, guidelines, and policy recommendations aimed at improving wildfire management and mitigating the most damaging effects of wildfires.

Objective 17 (O17) was defined to expand the EU-wide community of diverse stakeholders involved in wildfire management, including civil protection, fire and forest services, the timber/paper industry, forest owners, tourist resources, and insurance companies. This expansion facilitated the sharing of fire knowledge, research outputs, and best practices for fire management (WP5, WP6).

The associated **KPI** to measure the accomplishment of O17 **required the creation of a database with new players in existing fire expert communities and networks, such as architects, forest owners, the timber or paper industry, insurance companies, and tourist resources** (Annex A: Stakeholder networks, Table 11). The minimum KPI metric required the establishment of multi-partner networks in the five pilot sites, while the optimum KPI metric was the creation of multi-partner networks in the five pilot sites plus a multi-partner network empowered at the EU level. The demonstration events were scheduled as follows:

- **Pilot Sites Demonstration Events:**
  - June 7th, 2023: Barcelona, Spain.
  - November 3rd, 2023: Coimbra, Central Portugal.
  - January 26th, 2024: Central Europe.
  - May 7th, 2024: Fourth Pilot Site Demonstration Event in Northern Europe.
  - June 12th, 2024: Fifth Pilot Site Demonstration Event in Rafina, Greece.
  - September 16th, 2024: European Demonstration Event in Milan, Italy.
- **Other Events:**
  - September 29th, 2021: Webinar on Future Fire Scenarios and Biodiversity (Online).
  - December 2nd, 2021: Webinar on Major Fire Events of 2021 in the Mediterranean Basin (Online).
  - March 12th, 2022: Symposium on Forest Fires in Central Europe: Preparing for a New Reality; coinciding with the 4th Plenary Meeting. Dresden, Germany.
  - March 16th, 2022: Webinar on An Integrated Program of Wildfire Risk Management: The Case of Portugal (Online).
  - February 20th, 2023: Webinar on Spanish Strategy of Fire Risk Assessment, Reduction, and Adaptation (Online).
  - May 8, 2023rd: Webinar on Strategies towards Wildfire Risk Management: The Greek Experience (Online).
  - January 10th, 2024: Focus Group on "Wildfire Risk and Future Scenarios" with Local Experts; coinciding with the 8th Plenary Meeting. Alghero, Sardinia, Italy.
  - February 9th, 2024: Webinar on Wildfire Risk Management in Croatia (Online).
  - March 5th, 2024: Workshop on “Facing the Final Year: Lessons Learned and Expected Results”; coinciding with the 7th Plenary Meeting in Athens, Greece.

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

- March 10th, 2025. Online webinar on the "Information, Data and Visualisation tools" developed within the project, with data sets and standard products from all six demonstration areas. Includes FirEurisk Mobile App and project's WIKI pages.

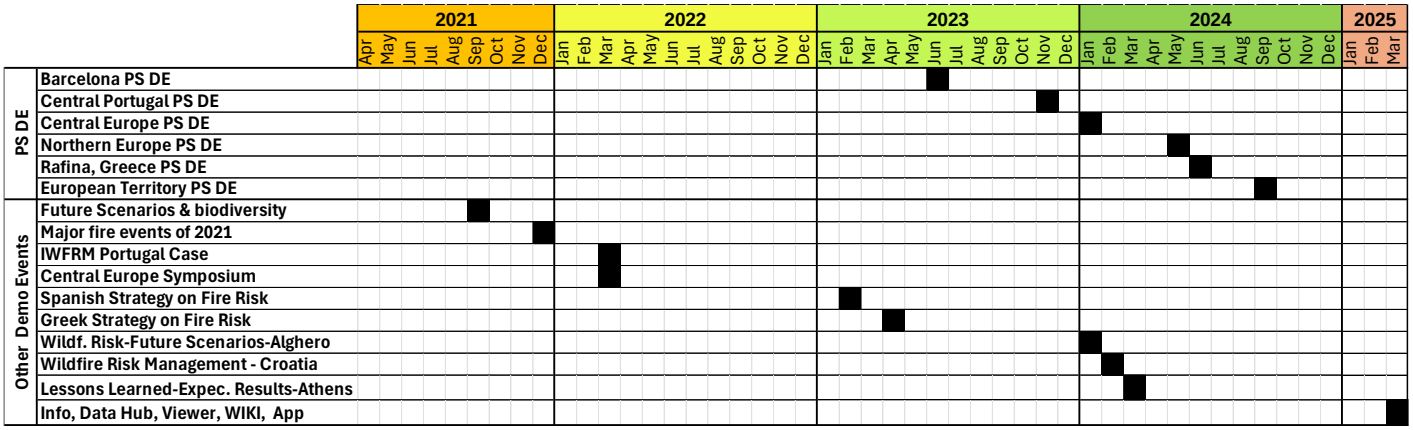


Figure 8. Overview of FirEURisk events

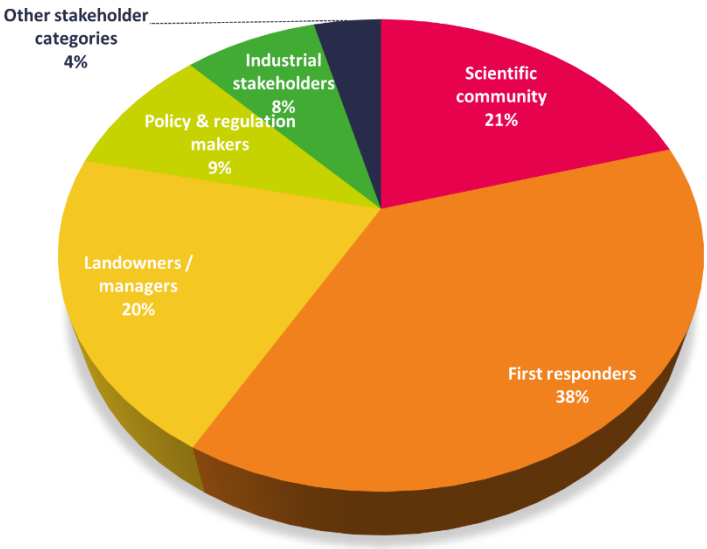


Figure 9. FirEUrisk network by stakeholder categories

Figure 9 depicts the stakeholders' categories of attendants to the demonstration events. The data indicates that the largest proportion of attendees, 37.64% (370 attendees), were First Responders, followed by the Scientific Community and Landowners/Managers, which account for 20.55% (202 attendees) and 20.35% (200 attendees) of the attendees, respectively. Policy and Regulation Makers comprise 9.36% (92 attendees) of attendees, while Industrial Stakeholders represent 8.04% (79 attendees). The remaining categories have significantly smaller proportions: Civil Society Organizations 2.85% (28 attendees), Risk Prevention Communities 0.51% (5 attendees), General Public 0.20% (2 attendees) and Hospital/Medical 0.41% (4 attendees).

Copyright © FirEURisk Consortium. All rights reserved.

Table 5: Number of attendants by countries and regions

Regions	Number of Attendants	%
Sweden (PS1)	7	0.7%
Czechia (PS2)	4	0.4%
Poland (PS2)	6	0.6%
Germany (PS2)	36	3.7%
Portugal (PS3)	678	69.0%
Spain (PS4)	62	6.3%
Greece (PS5)	14	1.4%
Other EU countries	101	10.3%
European Commission	9	0.9%
European Institutions	4	0.4%
Non-EU countries	21	2.1%
World	3	0.3%
Non-European countries	38	3.9%
Total	**983**	**100%**

Table 5 (above) and Figure 10 (below) list the country of origin of stakeholders.

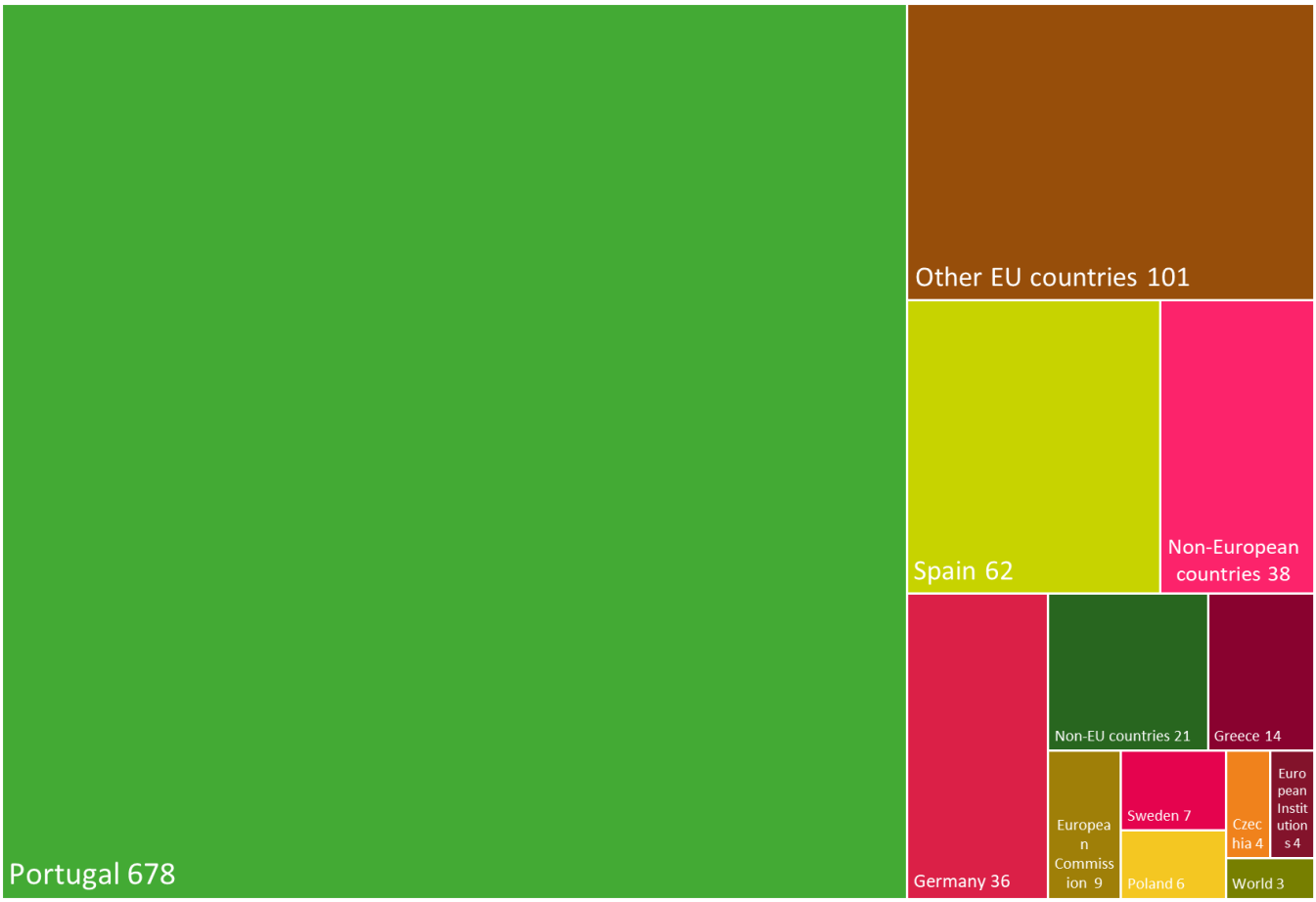


Figure 10. Overview of attendants by countries.

Copyright © FirEURisk Consortium. All rights reserved.

Portugal (PS3) stands out significantly, contributing the highest percentage of attendants at 69.04% (678 attendees), indicating a dominant presence compared to other countries, thus distorting somehow the percentual reads in other pilot sites. This is due to the extensive network of contacts that ADAI has, especially firefighting teams (including volunteers from fire brigades), civil protection, and local governments (mainly technicians from municipalities that have some responsibility in fire management), with a local, regional, and national scope of action.
Spain (PS4) is the second highest, with 6.31% (62 attendees) of the total attendants, which is considerably lower than Portugal but still notable. Spain is represented primarily by national and regional academic and research entities, particularly those from Catalonia and Andalusia.

In Central Europe (PS2), Germany, with 3.67% (36 attendees) has the highest attendance rate within this group, reflecting the strong influence of the PS leader. Czechia and Poland indicate a lower level of engagement, with 0.41% (4 attendees) and 0.61% (6 attendees), respectively. The Central European organizations covered sectors such as forestry, national parks, research, and higher education. The national parks attended represented three cross-border regions from Central Europe (Czechia/Germany, Czechia/Poland, and Czechia/Austria), highlighting an interest in transnational fire risk management across borders. There we attendants from Slovakia, Slovenia too.

Greece (PS5), contributing 1.43% (14 attendees), demonstrates a notable level of participation, surpassing many other countries yet still significantly lower than the leading nations. Among the Greek participants, institutions dedicated to research and academia, such as the National Observatory of Athens and the Agricultural University of Athens, are particularly prominent.

Sweden (PS1), with 0.71% (7 attendees), exhibits a moderate level of involvement, reflecting lower fire activity but maintaining a significant presence. Noteworthy among the Swedish representatives at the events are the Swedish Civil Contingencies Agency and the Forestry Research Institute of Sweden.

Other EU countries that were highlighted by their presence at the events include Italy (DA 1-9), with 3.77% (37 attendees), suggesting a strong representation from this country. France (DA 10-13), with 1.93% (19 attendees), also demonstrates a considerable level of attendance, indicating a strong interest in the event. Croatia (DA 20), contributing 1.02% (10 attendees), shows a moderate level of participation, reflecting a notable presence among the attendees. Other EU countries such as Austria (0.61%, 6 attendees), the Netherlands (0.61%, 6 attendees), Bulgaria (0.31%, 3 attendees), Finland (0.31%, 3 attendees), Hungary (0.31%, 3 attendees), and Cyprus (0.20%, 2 attendees) have moderate attendance rates. The European Commission and European Institutions collectively accounted for ca. 1.33% (13 attendees) of the attendants, indicating some level of institutional participation.

The "World" category, contributing 0.20% (2 attendees), represents a small but diverse group of attendants from international institutions (FAO, WB, and NCSD), highlighting the global reach and interest in the event. Non-European countries have much lower percentages, with the USA at 0.71% (7 attendees) and Australia at 0.51% (5 attendees) being the most notable among them. Non-EU countries account for 21 attendees, making up 2.1% of the total, while non-European countries contribute 38 attendees, representing 3.9% of the total.

Copyright © FirEURisk Consortium. All rights reserved.

2.4. Technical Readiness Level of Products

Demonstration events allowed a qualitative evaluation of the products, through a dynamic questionnaire with attendants. Thus, producers could evaluate the Technology Readiness Levels[4] (TRLs), as defined by the European Commission (Source: h2020-wp1415-annex-g-trl_en.pdf), that products reached at the end of the project, shown in Table 6 and

Figure 11 below. Out of the 62 products, 39 (63%) have a TRL of 4 or higher, while 23 products (37%) have incipient TRLs between 2 and 3.

Table 6. FirEURisk Products Technical Readiness Level (TRL) at the end of the project

Id	FirEURisk European (E), Regional (R) and Local (L) Products	Integration of fire risk components	Producer	TRL
R-10	Wildland-Urban Interface map	Exposure	HU	8
R-13	Maps of fire exposure metrics	Exposure	UAVR	8
E-1	Probability of Human Ignition, PHI	Danger	UAH	7
E-3	Live Fuel Moisture Content, LFMC	Danger	UAH	7
E-10	Ecological values, Eva	Vulnerability	UAH	7
E-12	Coping capacity, CC	Vulnerability	IRD	7
E-13	Recovery time, RT	Vulnerability	IRD	7
E-16	Handbook with guidelines to face extreme fires, and fires in Wildland-Urban Interface areas	Risk Mitigation	SAFE CLUSTER	7
E-19	FirEURisk Open Viewer	Instrumental	ARBONAUT	7
E-20	Laws, regulations, plans and programmes on fire prevention, preparedness and resilience	Instrumental	UC/ADAI	7
R-16	Fuel Management Framework for Reducing Operation-based Ignitions, FuMaF_ROI	Mitigation	AUTH	7
R-17	Land Management Strategies for Adriatic area	Mitigation	FESB SPLIT	7
R-22	Program of prescribed burnings	Instrumental	CNR IBE	7
R-23	Handbook with guidelines to face extreme fires, and fires in Wildland-Urban Interface areas	Instrumental	FESB SPLIT	7
L-2	Fire danger index classification for Chornobyl Exclusion Zone	Danger	REEFMC	7
L-7	DSS ChEZ REEFMC	Danger	REEFMC	7
L-8	WEPPcloud-EU-WATAR	Exposure	SU	7
E-17	Fire behaviour predictive models	Risk Mitigation	ADAI	6
R-21	Forest condition biotic damages	Instrumental	GMV	6
L-1	Daily Fire Danger Index	Danger	SIA	6

[4] TRLs are a systematic metric used to assess the maturity of a particular technology, ranging from TRL 1, where basic principles are observed, to TRL 9, where the technology is fully mature and operational. Each level represents a stage in the development process, from initial concept and experimental proof of concept (TRL 1-3), through validation in laboratory and relevant environments (TRL 4-6), to demonstration in operational settings (TRL 7-9). This framework provides a consistent and uniform approach to evaluating technological progress, ensuring that innovations are adequately developed and tested before full-scale deployment.

Copyright © FirEURisk Consortium. All rights reserved.

Id	FirEUrisk European (E), Regional (R) and Local (L) Products	Integration of fire risk components	Producer	TRL
R-4	Fuel type, fuel model, canopy metrics and landscape file	Danger	UdL	5
R-18	Future climate information	Adaptation	METEOGRID	5
R-19	Future fire regime database	Adaptation	PIK	5
L-6	Spring grass fire model for the North	Danger	RISE	5
L-11	Potential Losses on Ecosystem Services affected by wildfires	Vulnerability	UCO	5
L-12	Suppression Difficulty Index Evaluation	Vulnerability	UCO	5
L-14	Factors for building survivability in Scandinavia	Mitigation	RISE	5
L-15	Fire risk and strength predictions: short-term & long-term	Adaptation	FMI	5
L-16	Effective adaptation to changed future fire regimes	Adaptation	PIK	5
L-18	Citizens scientist network and Engagement Plan	Instrumental	ISIG	5
E-4	Fuel Classification Map, FCM	Danger	UAH	4
E-5	Fuel Models, FBFM40	Danger	UAH	4
E-6	Canopy Fuel Parameters, CFP	Danger	UAH	4
E-14	Integrated fire risk index, IRI	Risk Assessment	UAH	4
R-5	Fire danger metric	Danger	UdL	4
R-8	Smoke potential	Danger	UAVR	4
R-9	Fire emission potential	Danger	UAVR	4
R-20	High resolution future climate information for Greece	Adaptation	NCSR	4
L-5	Canopy metrics and terrain files	Danger	ARBONAUT	4
E-2	Probability of Natural Ignition, PNI	Danger	UAH	3
E-7	Propagation Potential Indicators for European Territory, PP-ET	Danger	FESB SPLIT	3
E-15	Maps of Suitability of Fuel-Relevant Land Management Strategies in Europe	Risk Mitigation	VUA	3
E-18	Continental land-use change scenarios and stylized fuel management scenarios	Risk Adaptation	VUA	3
R-1	Human ignition probability for Pilot Sites	Danger	UdL	3
R-2	Live-fuel moisture content climate archive	Danger	TUD	3
R-3	Fuel Sampling Protocol	Danger	CNR IBE	3
R-6	Wildfire spread and behaviour, FlamMap	Danger	UdL	3
R-7	Propagation potential indicators for Pilot Sites, PP-PS	Danger	FESB SPLIT	3
R-11	Forest fire emission forecast	Exposure	UAVR	3
R-12	Smoke dispersion forecast	Exposure	UAVR	3
R-14	Relative Societal Vulnerability Index (RESVI) at community level	Vulnerability	ISIG	3
R-15	Persistence Index Map	Vulnerability	UdL	3
L-3	Custom fuel characterization	Danger	UdL	3
L-9	Forecast of health impacts of wildfire smoke	Exposure	UAVR	3
L-10	Geospatial integrated eruptive fire risk map and merging fires risk map	Exposure	FESB SPLIT	3
L-13	Guidelines for citizens involvement in wildfire risk reduction	Mitigation	FESB SPLIT	3
L-17	Analysis of potential socio-economic barriers, constrains and enables of Land Management Strategies uptake to reduce fire risk	Instrumental	HUTTON	3
L-19	Guidelines for on-site surveys and subsequent data processing	Instrumental	ADAI	3

Copyright © FirEUrisk Consortium. All rights reserved.

Id	FirEUrisk European (E), Regional (R) and Local (L) Products	Integration of fire risk components	Producer	TRL
E-8	Exposure, E	Exposure	HU	2
E-9	Ecosystem services, ESva	Vulnerability	HU/UAH	2
E-11	Houses value, HV	Vulnerability	HUTTON/UAH	2
L-4	Fuel type and fuel models map	Danger	INCDS	2

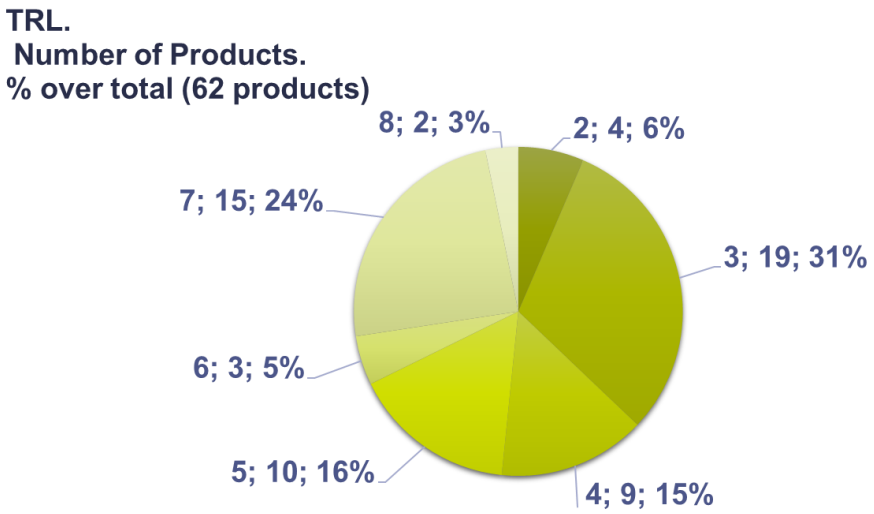


Figure 11. Number of products per TRL. Percentage over total (62 products)

Having components with different Technology Readiness Levels (TRLs) in the same portfolio needs a closer analysis, since it entails both advantages and challenges, as summarised in Table 7 below. The analysis of TRLs traces a roadmap for the short-term technological uptake of the integrated solution. Strategies for the complete technological uptake could cover aspects such as:

- Phased development and deployment, deploying high-TRL products first as the backbone of the solution,
- Planning a robust system integration, allowing frequent integration tests to monitor the performance of components,
- Re-test the upgraded solution for the whole European territory, communicating and training the results with the stakeholders.

Copyright © FirEUrisk Consortium. All rights reserved.

Table 7. Pros and Cons of the different TRLs in the FirEUrisk European Core Products Portfolio

Analysis of the different TRLs in the FirEUrisk European Core Products Portfolio	
Pros	Cons
Innovation and Flexibility • Lower TRL products (early-stage technologies) allow for innovation and the integration of cutting-edge solutions. • High TRL products (mature technologies) provide a stable foundation, ensuring reliability.	**Integration challenges** • Combining products at different TRLs can lead to compatibility issues, requiring additional effort in system integration • Some low TRL products may eventually be substituted
Cost Efficiency • Mature products reduce the need for extensive testing, saving time and resources. • Early-stage products can be developed incrementally, spreading costs over time.	**Uneven performance** • Lower TRL products may underperform or fail, potentially impacting the overall solution's effectiveness.
Scalability • Combining technologies at different TRLs allows for phased implementation, enabling gradual scaling and adaptation	**Resource allocation** • Balancing resources between developing early-stage technologies and maintaining mature ones can be complex.
Risk diversification • A mix of TRLs spreads the risk, as mature products can compensate for uncertainties in less developed ones.	**Extended timelines** • Early-stage products may require significant development time, delaying the full deployment of the solution.
Stakeholder engagement • Demonstrating a mix of readiness levels can attract diverse stakeholders, from researchers to policymakers, fostering collaboration.	**Uncertainty in Outcomes** • The success of the solution may hinge on the successful maturation of lower TRL products, introducing uncertainty.

Copyright © FirEUrisk Consortium. All rights reserved.

3. Portfolio of European Core Products for an Integrated Wildfire Risk Management Strategy

3.1. Summary of the portfolio

An integrated wildfire risk management strategy is a complex multifactor endeavour. The number of factors and variables can turn the mission in a maze leading nowhere. Hence the importance of the integration scheme and semantics followed throughout the project, including the three dimensions of risk, i.e.: danger, exposure and vulnerability. This section presents **FirEURisk European Core Products Portfolio**, with 20 products**.** Figure 12 below traces each product to the specific wildfire integration factor in the integration schema.

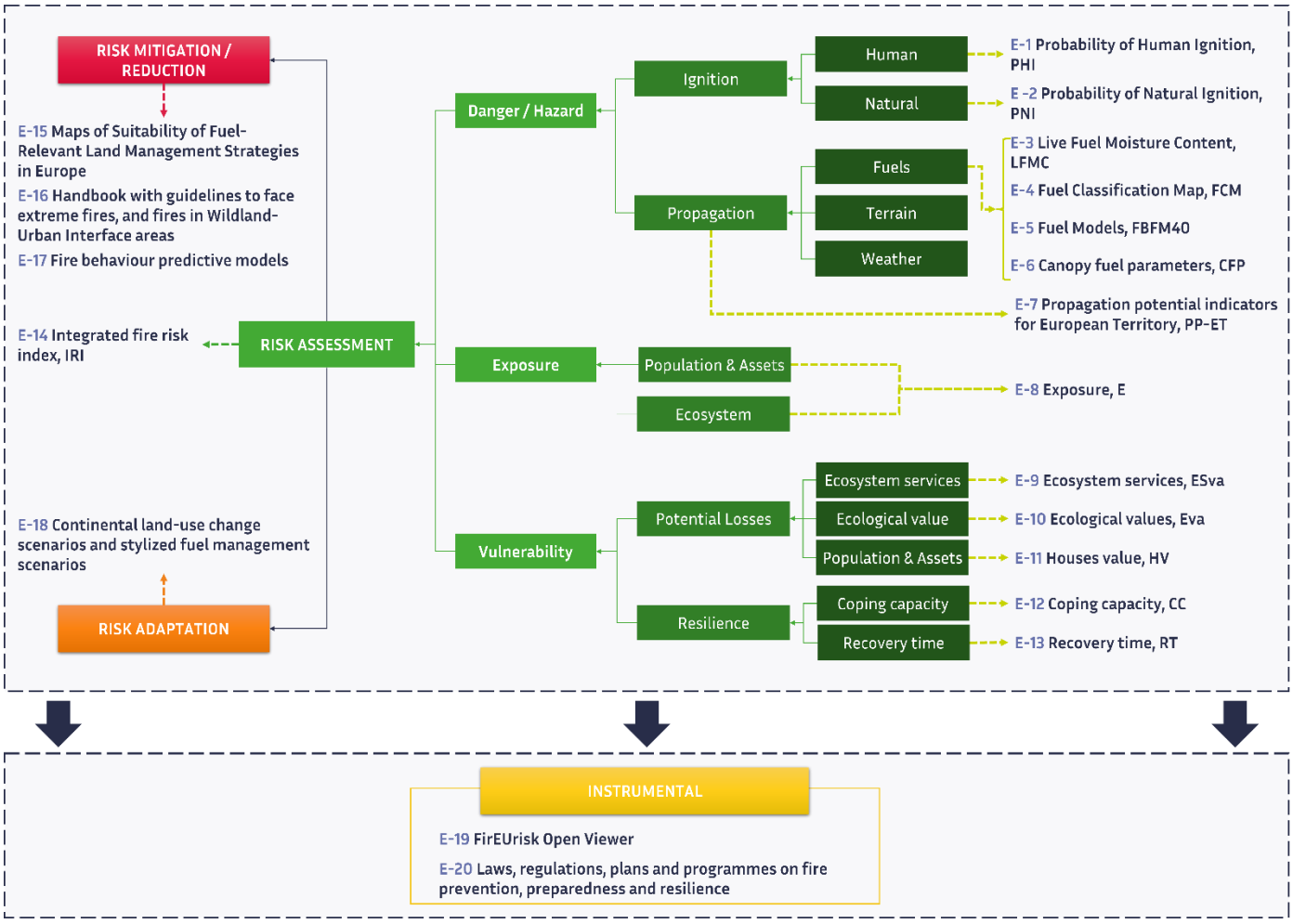


Figure 12. FirEURisk European Core Products schema.

Copyright © FirEURisk Consortium. All rights reserved.

Table 8 lists the **European Core Products** traced to the fire risk component, the producer, and the Technology Readiness Levels[5] (TRLs) as defined by the European Commission (Source: h2020-wp1415-annex-g-trl_en.pdf).

Table 8. FirEUrisk European Core Products Portfolio

Id	FirEUrisk European Core Products	Integration of fire risk components	Producer	TRL
E-1	Probability of Human Ignition, PHI	Danger	UAH	TRL 7
E-2	Probability of Natural Ignition, PNI	Danger	UAH	TRL 3
E-3	Live Fuel Moisture Content, LFMC	Danger	UAH	TRL 7
E-4	Fuel Classification Map, FCM	Danger	UAH	TRL 4
E-5	Fuel Models, FBFM40	Danger	UAH	TRL 4
E-6	Canopy Fuel Parameters, CFP	Danger	UAH	TRL 4
E-7	Propagation Potential Indicators for European Territory, PP-ET	Danger	FESB SPLIT	TRL 3
E-8	Exposure, E	Exposure	HU	TRL 2
E-9	Ecosystem services, ESva	Vulnerability	HU/UAH	TRL 2
E-10	Ecological values, Eva	Vulnerability	UAH	TRL 7
E-11	Houses value, HV	Vulnerability	HUTTON/UAH	TRL 2
E-12	Coping capacity, CC	Vulnerability	IRD	TRL 7
E-13	Recovery time, RT	Vulnerability	IRD	TRL 7
E-14	Integrated fire risk index, IRI	Risk Assessment	UAH	TRL 4
E-15	Maps of Suitability of Fuel-Relevant Land Management Strategies in Europe	Risk Mitigation	VUA	TRL 3
E-16	Handbook with guidelines to face extreme fires, and fires in Wildland-Urban Interface areas	Risk Mitigation	SAFE CLUSTER	TRL 7
E-17	Fire behaviour predictive models	Risk Mitigation	ADAI	TRL 6
E-18	Continental land-use change scenarios and stylized fuel management scenarios	Risk Adaptation	VUA	TRL 3
E-19	FirEUrisk Open Viewer	Instrumental	ARBONAUT	TRL 7
E-20	Laws, regulations, plans and programmes on fire prevention, preparedness and resilience	Instrumental	UC/ADAI	TRL 7

The sections below provide a full description of each product of the FirEUrisk European Core Products Portfolio

[5] TRLs are a systematic metric used to assess the maturity of a particular technology, ranging from TRL 1, where basic principles are observed, to TRL 9, where the technology is fully mature and operational. Each level represents a stage in the development process, from initial concept and experimental proof of concept (TRL 1-3), through validation in laboratory and relevant environments (TRL 4-6), to demonstration in operational settings (TRL 7-9). This framework provides a consistent and uniform approach to evaluating technological progress, ensuring that innovations are adequately developed and tested before full-scale deployment.

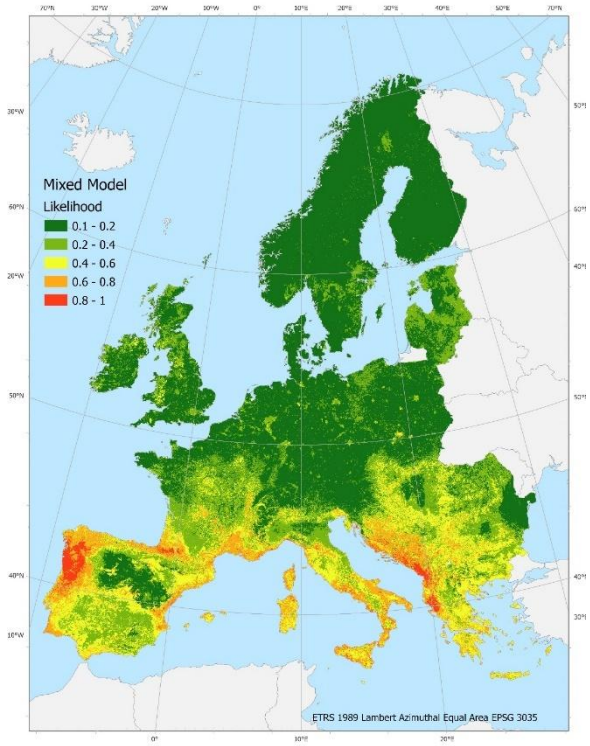
Copyright © FirEUrisk Consortium. All rights reserved.

3.2. Danger or hazard products

3.2.1. Probability of Human Ignition, PHI

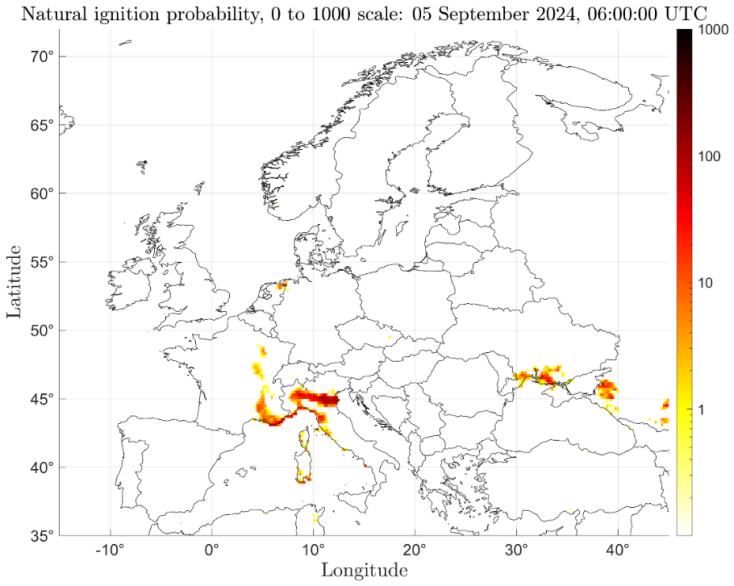
<table>
<tr><td>Description</td><td>It’s a probabilistic map estimated from a random forest model using human and climate variables. The likelihood of ignitions map (scale 0 to 1) has a spatial resolution of 1 km^2.</td></tr>
<tr><td>Type & format</td><td>Geospatial (.tif)</td></tr>
<tr><td>Units</td><td>Probability scale 0 to 1</td></tr>
<tr><td>Update Frequency</td><td>Static layer</td></tr>
<tr><td>Estimated Accuracy</td><td>80%</td></tr>
<tr><td>Temporal coverage</td><td>2001-2019</td></tr>
<tr><td>Spatial resolution</td><td>1 km^2</td></tr>
<tr><td>Methodology</td><td>The product estimates the probability that a human caused fire will be ignited. The product was developed using Random Forest algorithm based on socio-economic and climatic drivers of ignition from geospatial indicators and demographic databases, listed below.
<table>
<tr><th>Variable</th><th>Source</th><th>Year</th></tr>
<tr><td>1. Distance to roads</td><td>GLOBIO Model</td><td>2018</td></tr>
<tr><td>2. Forest-Agricultural Interface, FAI</td><td>FirEUrisk model Fuel Map</td><td>2019</td></tr>
<tr><td>3. Wildland-Urban Interface, WUI</td><td>FirEUrisk WUI</td><td>2022</td></tr>
<tr><td>4. Wildland-Agricultural Interface, WAI</td><td>FirEUrisk model Fuel Map</td><td>2019</td></tr>
<tr><td>5. Wildland-Forest Interface, WFI</td><td>FirEUrisk model Fuel Map</td><td>2019</td></tr>
<tr><td>6. Forest-Urban Interface, FUI</td><td>FirEUrisk model Fuel Map</td><td>2019</td></tr>
<tr><td>7. Land change</td><td>Corine Land Cover</td><td>2000 & 2018</td></tr>
<tr><td>8. Cattle/km^2</td><td>FAO</td><td>2010</td></tr>
<tr><td>9. Goats/km^2</td><td>FAO</td><td>2010</td></tr>
<tr><td>10. Sheep/km^2</td><td>FAO</td><td>2010</td></tr>
<tr><td>11. GDP (2011, USD millions)</td><td>Aalto University, Helsinki</td><td>2015</td></tr>
<tr><td>12. Population > 65 years</td><td>SEDAC-CIENSIN Data Base, NASA</td><td>2010</td></tr>
<tr><td>13. Population density</td><td>GEOSTAT 2018, GISCO.</td><td>2018</td></tr>
<tr><td>14. Evapotranspiration</td><td>CMIP6-based global estimates</td><td>2018</td></tr>
<tr><td>15. Aridity Index</td><td>CMIP6-based global estimates</td><td>2018</td></tr>
<tr><td>16. Bioclimates</td><td>European Commission /University of Edinburgh</td><td>2000</td></tr>
<tr><td>17. Ecological Regions</td><td>FAO</td><td>2000-2010</td></tr>
</table>
The model obtained a performance of 80% estimated by the area under the curve (AUC). The model uses all ignitions that generated burned areas > 100 ha for a total of 33,388 ignitions. In addition, different data balancing methods were tested for the training, the stratified method being the most suitable for this model. This method consists of using a descriptive layer of European ecological regions to obtain a more representative sample of absence points. The results of the climate model showed that the probability of ignition in northern Europe is masked, the human models encountered challenges with classification accuracy, suggesting that the RF algorithm struggled to make accurate predictions based solely on human variables. These findings imply that predicting large fires initiations across broad geographic extents may not be feasible with human variables alone, highlighting the necessity of including climatic variables. This</td></tr>
</table>

Copyright © FirEUrisk Consortium. All rights reserved.

	limitation depends on the scale of the analysis, as it dictates the magnitude of potential environmental gradients that drive initiation patterns. Whereas the mixed model proved to be the best candidate to represent the probability at the European scale. This might be because climatic variables help the model to differentiate between northern and southern Europe and thus find patterns in the data. It is important to note that by using the mixed models, areas of high probability are seen in northern Europe, which would otherwise be masked. Because of the results, we suggest the use of mixed models for global studies.
Contact	Clara Ochoa, UAH: mclara.ochoa@uah.es Avi Bar-Massada, HU: avi-b@sci.haifa.ac.il
Publication	[2] Ochoa, C., Bar-Massada, A., & Chuvieco, E. (2024). A European-scale analysis reveals the complex roles of anthropogenic and climatic factors in driving the initiation of large wildfires. Science of the total environment, 170443. https://doi.org/10.1016/j.scitotenv.2024.170443
Overview	

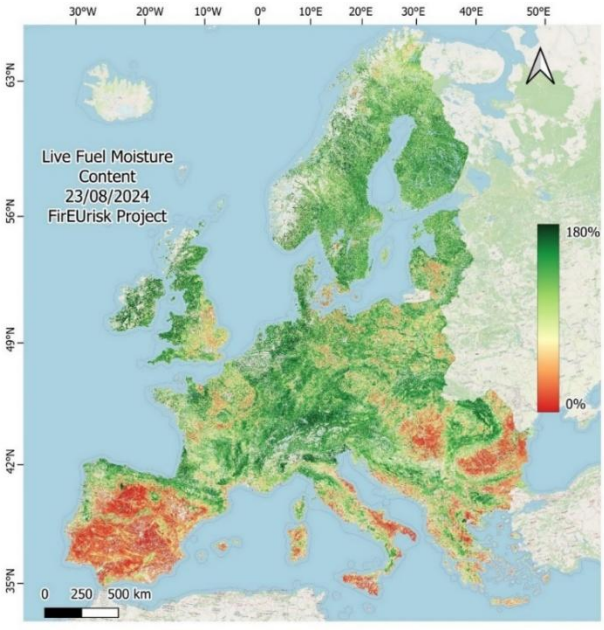
Copyright © FirEURisk Consortium. All rights reserved.

3.2.2. Probability of Natural Ignition, PNI

Description	The Fire Forecasting Model (FFM, Sofiev et al, in prep.)-based Natural Ignition Probability product predicting the wildfires ignition probability by natural causes through basic meteorological parameters provided by Numerical Weather Predicting models.
Type & format	Geospatial (.nc4)
Units	Probability on 0 to 1000 scale
Update Frequency	Daily
Estimated Accuracy	50%
Temporal coverage	06.06.2018 – today
Spatial resolution	~ 9 km
Methodology	FFM employs a multi-step machine learning procedure to construct a statistical model that predicts Fire Radiative Power (FRP) based on global ERA5 reanalysis, ERA5-Land reanalysis, IFS operational forecast, and Terra's Moderate Resolution Imaging Spectroradiometer (MODIS, MOD14/MYD14 - collection 6). The model utilizes various meteorological parameters, including Cloud-to-Ground Lightning Flash Density and Fire Danger Indices, as predictors for training and making predictions by calculating their respective contributions to total FRP. The contribution of cloud-to-ground lightning flash density to FRP is then used as a proxy for natural ignition probability.
Contact	Evgeny Kadantsev, FMI: evgeny.kadantsev@fmi.fi
Publication	The product validation is still ongoing, the historical reanalysis and operational forecast will be publicly available through https://silam.fmi.fi/ website and FirEURisk project platform.
Overview	

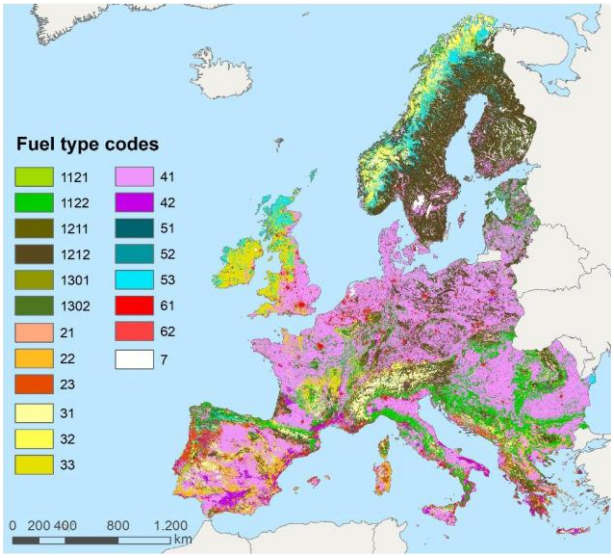
Copyright © FirEURisk Consortium. All rights reserved.

3.2.3. Live Fuel Moisture Content, LFMC

Description	Radiative Transfer Model (RTM)-based Live Fuel Moisture Content (LFMC) product based on the Sentinel-3 Synergy and Sentinel-2 L2A surface reflectance product and a Look-Up Table (LUT)-based inversion procedure.
Type & formats	Geospatial (.tif, .nc)
Units	% moisture content
Update Frequency	~ Daily (Sentinel-3) and ~ Weekly (Sentinel-2)
Estimated Accuracy	80-90%
Temporal coverage	2018-today (Sentinel-3) and 2016-today (Sentinel-2)
Spatial resolution	1 km (Sentinel-3) and 100 m (Sentinel-2)
Methodology	This product is based on the inversion of Look-Up Tables (LUT) created using a combination of the PROSPECT-D, 4SAIL RTMs and a modified version of Huemmrich's GeoSail, and convolving the calculated reflectances in the Sentinel-3 SYNERGY and Sentinel-2 MSI channels. The LUTs change depending on the land cover type: PROSPECT-D and 4SAIL are used for grasslands and shrublands, while for forests the 4SAIL output is fed into the Geo component to simulate discontinuous vegetation. The LUT inversion is performed using Random Forest Regression algorithms [3].
Contact	Valerio Pampanoni, SIA: valerio.pampanoni@uniroma1.it
Publication	[4] Pampanoni, Valerio, et al. "Using Prosail Look-Up Tables to Train Random Forests Regressors for Fast Live Fuel Moisture Retrieval." IGARSS 2024-2024 IEEE International Geoscience and Remote Sensing Symposium. IEEE, 2024. https://doi.org/10.1109/IGARSS53475.2024.10642386.
Overview	

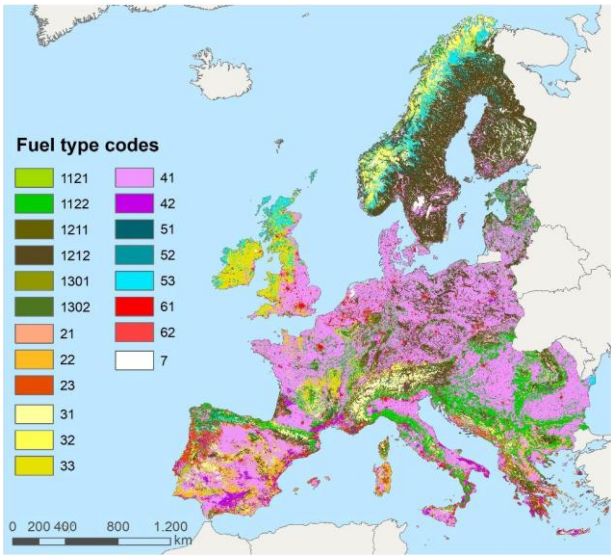
Copyright © FirEUrisk Consortium. All rights reserved.

3.2.4. Fuel Classification Map, FCM

Description	The product includes the fuel type and parameters following the standard classification of fuels for the European territory. The final outputs are fuel classes and static fuel map with the spatial resolution of 1 km^2.
Type & format	Geospatial (.tif)
Units	Fuel classes
Update Frequency	Static layer
Estimated Accuracy	88.4%.
Temporal coverage	Developed for 2020
Spatial resolution	1 km^2
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
Contact	Elena Aragoneses de la Rubia, UAH: e.aragoneses@uah.es
Publication	[5] 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, 1287–1315.
Overview	

Copyright © FirEURisk Consortium. All rights reserved.

3.2.5. Fuel Models, FBFM40

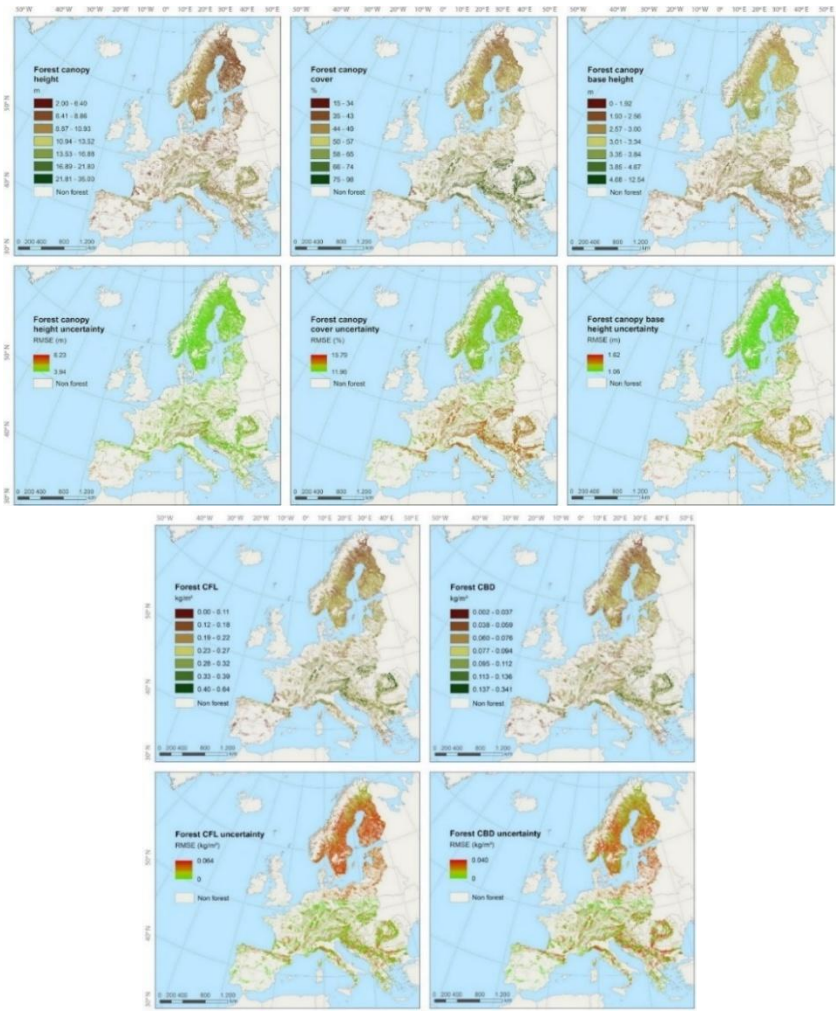
Description	The product includes the fuel type and parameters following the standard classification of fuels for the European territory. The final output – fuel classes and static fuel map with the spatial resolution of 1 km^2.
Type & format	Geospatial (.tif)
Units	Fuel classes
Update Frequency	Static layer
Estimated Accuracy	88.4%
Temporal coverage	Developed for 2020
Spatial resolution	1 km^2
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
Contact	Elena Aragoneses de la Rubia, UAH: e.aragoneses@uah.es
Publication	[5] 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, 1287–1315.
Overview	

Copyright © FirEURisk Consortium. All rights reserved.

3.2.6. Canopy Fuel Parameters, CFP

Description	The dataset of European canopy fuel parameters, at 1 km spatial resolution, encompasses a total of 10 maps including: forest canopy height, canopy cover, canopy base height, canopy fuel load and canopy bulk density with their associated uncertainties. They have been generated by integrating GEDI with other sensors. Further details about the generation of these maps can be read in Aragoneses et al 2024 [6] and Aragoneses et al. 2025 [7]. These maps complement the categorical information of the FirEUrisk European fuel type map for the forest fuel types in Aragoneses et al. (2023) [5].
Type & format	Geospatial (.tif)
Units	Canopy height, canopy height base and its uncertainties: metres. Canopy cover and its uncertainty: parts per unit (which is the same as percentage expressed as decimal). Canopy fuel load and canopy bulk density and its uncertainties: kg/m^2.
Update Frequency	No update
Estimated Accuracy	GEDI vs canopy height: rRMSE = 13.23-19.75 %. GEDI vs canopy cover: rRMSE = 16.26 %. GEDI vs canopy base height: rRMSE = 39.80 %. Spatial extrapolation (rRMSE = 28.43-30.66 % for canopy height; rRMSE = 10.65-14.42 % for canopy cover; rRMSE = 19.16-22.93 % for canopy base height). GEDI vs canopy bulk density: rRMSE = 33.1 – 59-6 %). Spatial extrapolation (rRMSE = 12.98 % for canopy fuel load; rRMSE = 21 % for canopy bulk density).
Temporal coverage	Circa 2020
Spatial resolution	1 km
Methodology	Spatially explicit data on forest canopy fuel parameters provide critical information for wildfire propagation modelling, emission estimations and risk assessment. We developed a two-step, easily replicable methodology to estimate forest canopy fuel parameters (canopy height, canopy cover and canopy base height) for the entire European territory, based on data from the Global Ecosystem Dynamics Investigation (GEDI) sensor, onboard the International Space Station (ISS). First, we simulated GEDI pseudo-waveforms from discrete Airborne Laser Scanning (ALS) data over forest plots. We then used metrics derived from the GEDI pseudo-waveforms to estimate mean canopy height, canopy cover and canopy base height, for which we used national forest inventory and airborne LiDAR as reference data. The second stage was to generate wall-to-wall maps of canopy fuel parameters at 1 km resolution using a spatial interpolation of GEDI-based estimates for polygons with GEDI footprints within. For those polygons for which GEDI observations were not available (mainly Northern latitudes, above 51.6ºN), the parameters were estimated using random forest regression models based on multispectral and SAR imagery and biophysical variables. Uncertainty maps for the estimated parameters were provided at the grid level, considering the propagation of individual errors for each step in the methodology. The final outputs provide a wall-to-wall estimation for the continent of Europe of three critical parameters for modelling crown fire propagation potential and demonstrate the capacity of GEDI observations to improve the characterisation of fuel models. For canopy fuel load (CFL) and canopy bulk density (CBD) we integrate satellite GEDI measurements, with multispectral (Landsat 8) and radar (Phased Array L-band Synthetic Aperture Radar sensor – PALSAR) images, and biophysical data to provide spatially-explicit estimates of two key descriptors of crown fire behaviour — covering the whole European territory at 1 km^2 grid resolution. GEDI L1B and L2A level

Copyright © FirEUrisk Consortium. All rights reserved.

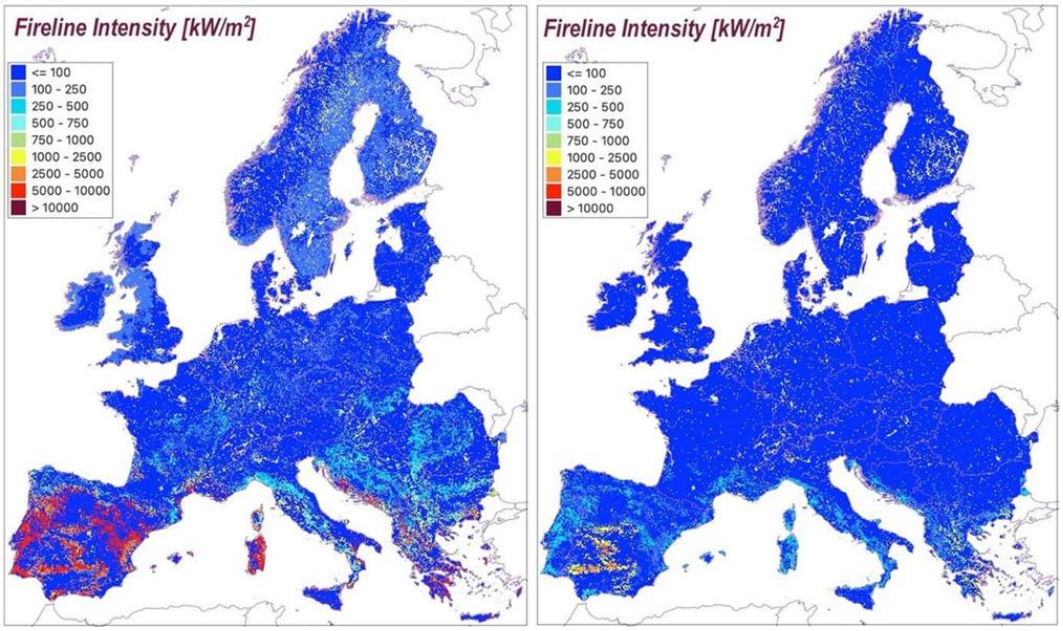
	footprints were used to estimate Leaf Area Density, from which CFL and CBD were subsequently derived. We then extrapolated the estimates to European areas not covered by GEDI using machine learning models with multispectral and radar imagery and biophysical variables. Pixel-level uncertainty for the spatial extrapolation was also estimated by modelling the root mean squared error of the spatial extrapolation models.
Contact	Elena Aragoneses de la Rubia, UAH: e.aragoneses@uah.es
Publication	[6] Aragoneses, E., García, M., Ruiz-Benito, P., & Chuvieco, E. (2024). Mapping forest canopy fuel parameters at European scale using spaceborne LiDAR and satellite data. Remote Sensing of Environment, 303, 114005. [7] Aragoneses, E., García, M., Tang, H., & Chuvieco, E. (2025). A multi-sensor approach allows confident mapping of forest canopy fuel load and canopy bulk density to assess wildfire risk at the European scale. Remote Sensing of Environment, 318, 114578. **Datasets:** Aragoneses, E., García, M., & Chuvieco, E (2024), FirEUrisk_canopy_fuel_parameters: canopy height, canopy cover and canopy base height, https://doi.org/10.21950/KTALA8, e-cienciaDatos, V1.
Overview	

Copyright © FirEURisk Consortium. All rights reserved.

3.2.7. Propagation potential indicators for European Territory, PP-ET

Description	This product will include GeoTIFF raster maps of propagation potential indicators for European Territory, as well as report with detail description of methodology and obtained results. Propagation potential for EU territory will be calculated in 1km^2 resolution, based past fires on EU territory from Jan 1st, 2001 to Dec 31st, 2019, fires larger than 2000 ha were selected. Outputs are typical surface fire propagation potential indicators, as well as crown fire propagation potential indicators.
Type & format	Geospatial (.tif)
Units	Not applicable
Update Frequency	If needed
Temporal coverage	Static layers
Spatial resolution	1 km
Methodology	Propagation potential for EU territory is calculated in 1 km2 resolution, based on custom implementation of Rothermel's surface fire model and various crown fire models (in Python) for cell-based wildland landscape fire growth simulations. From the list of past fires on EU territory from Jan 1st, 2001, to Dec 31st, 2019, fires larger then 2000 ha were selected. There were 403 of such fires. For their dates, maps of meteorological parameters were extracted from ERA5 and resampled to 1 km resolution. 10h Fuel Moisture Content and wind speed were calculated for each date, based on two weather scenarios: average weather conditions (50th percentile) and extreme weather conditions (5th percentile for fuel moisture and 95th percentile for wind speed). Input maps were wind speed and direction, 10h dead fuel moisture, slope, aspect, fuel models, Canopy Cover (CC), Canopy Height (CH), Canopy Base Height (CBH) and Canopy Bulk Density (CBD). Outputs are typical surface propagation potential indicators: Rate of Spread – R [m/s], Reaction intensity – RI [kW/m^2], Fireline Intensity – FI [kW/m] and Flame Length – FL [m] and crown fire propagation potential indicators: Crown Fraction Burned (CFB) [fraction], Crown Fire Activity (CFA), Crown Fire Rate of Spread [m/s], Crown Fire Heat per Unit Area [kJ/m^2], Crown Fire Flame Length (m) and Crown Fire Fireline Intensity [kW/m]. The same as accuracy of input maps (fuel maps, weather data maps). Internal Quality Control: Internal validation by historical fires. External stakeholder validation: Firefighters of Dalmatia Counties that use wildfire surveillance and monitoring system. Satisfaction questionnaires on product usability filled in by the stakeholder.
Contact	Darko Stipanicev, FESB SPLIT: dstip@fesb.hr Marin Bugarić, FESB SPLIT: marin.bugaric@fesb.hr

Copyright © FirEURisk Consortium. All rights reserved.

Overview	

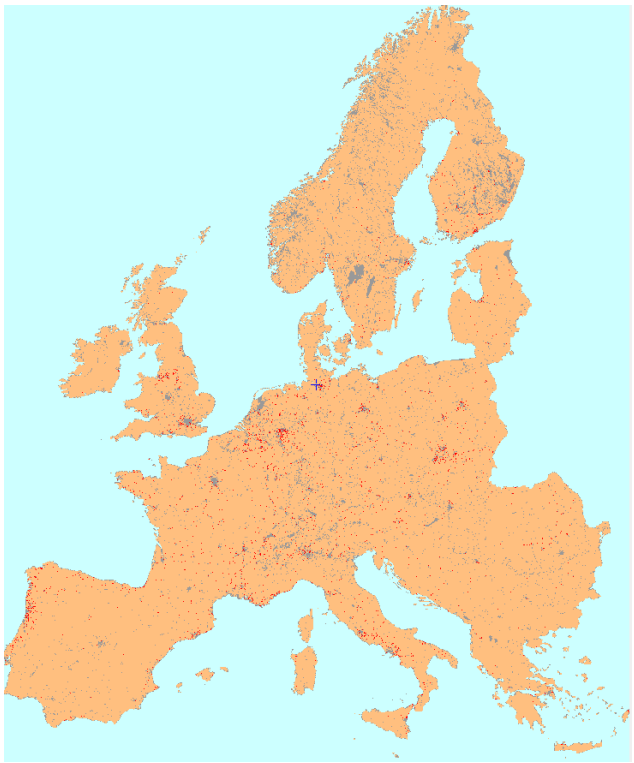
Copyright © FirEURisk Consortium. All rights reserved.

3.3. Exposure product

3.3.1. Exposure, E

Description	This cartographic product estimates Exposure based on a simple approach that considers the resources potentially exposed to wildfire effects. Even though different methods have been proposed to estimate this variable (Chuvieco et al. 2023), within this version of the integrated risk component only three categories of exposure were considered, given them a certain weight in relation to the importance of being potentially affected by fire: • Unburnable (code 0), including water, bare soil and urban dense. • Burnable (code 0.8), including all vegetation categories that are susceptible of being burned. • Burnable and with Wildland Urban Interface (WUI (Code 1). Includes burnable categories within a radius of 1 km of an urbanised area.
Type & format	Geospatial (.tif)
Units	Three categories: 0, 0.8, and 1.
Update Frequency	Not decided
Temporal coverage	2021
Spatial resolution	1 km
Methodology	For mapping the WUI at ET scale, the extension of the urbanized area was mapped, based on the 2019 World Settlement Footprint dataset (WSF). This dataset was generated by automated interpretation of 10-m resolution Sentinel-1 and Sentinel-2 satellite imagery, and each pixel is either built-up or not. Next, vegetation data was gathered from the 2020 European Space Agency (ESA) global land cover product [8]. This dataset is a classification of the same 10-m Sentinel-1 and Sentinel-2 satellite imagery, in conjunction with auxiliary data, into 11 land cover classes. This dataset was reclassified into two classes: woody vegetation classes ('forests' and 'shrublands', "1") and others ("0"). Hence, the research focused on fire hazard only from woody vegetation, regardless of species identity and fuel characteristics. The most common approach for WUI mapping distinguishes between WUI intermix and interface classes [9]. An intermix WUI is a unit area that: (1) comprises enough buildings exposed to wildfire risk; and (2) contains or is directly surrounded by sufficient amounts of flammable vegetation. An interface WUI is a unit area that contains buildings that are not directly surrounded by flammable vegetation yet is within a relatively short distance from a contiguous patch of flammable vegetation which can produce firebrands. To map the WUI, the parameters of the existing point-based WUI mapping approach were modified [10], which is based on the original US WUI mapping approach. The new approach adapts the 10 m-cell grid of the underlying datasets and includes the following steps: 1. Including all cells within 100 m of a built-up cell as candidate WUI locations, regardless of the housing density within (and around) them in order to identify all built-up areas that are potentially at risk. 2. Calculating the percent cover of woody vegetation within a 500 m radius around candidate WUI location cells; if woody cover was greater than 50%, these cells were mapped as 'intermix WUI'.

Copyright © FirEURisk Consortium. All rights reserved.

	3. Identifying patches of woody vegetation that were larger than 5 km^2. 4. Identifying all candidate WUI locations that were within 600 m to large vegetation patches; these cells were mapped as 'interface WUI'. The choice of 600 m reflects findings about the approximate median value of maximum travel distances of flying embers. This threshold differs from the previously used distance of 2,400 m [9], [11], which reflects maximum travel distances. The result of this process is a WUI map at either PS scale (if built-up information was based on individual buildings; five WUI maps overall) or ET scale (when the input was the WSF dataset; one WUI map for the entire ET) bas. Based on these maps, we quantified the overall extent and the spatial distribution of interface, intermix, and total WUI at the country level for each country in our study area. We also calculated the variation in WUI cover within countries, by overlaying a map of statistical regions at NUTS-3 level obtained from Eurostat, the EU's statistical agency. The WUI maps generated here are available for download in the project's data repository.
Contact	Clara Ochoa, UAH: mclara.ochoa@uah.es Avi Bar-Massada, HU: avi-b@sci.haifa.ac.il
Overview	

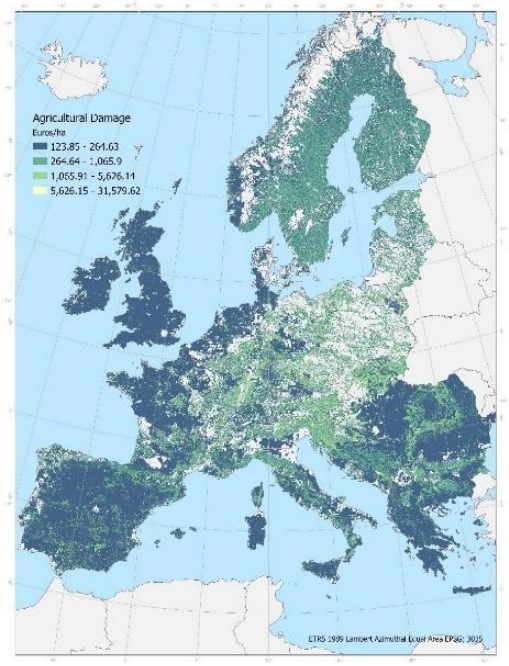
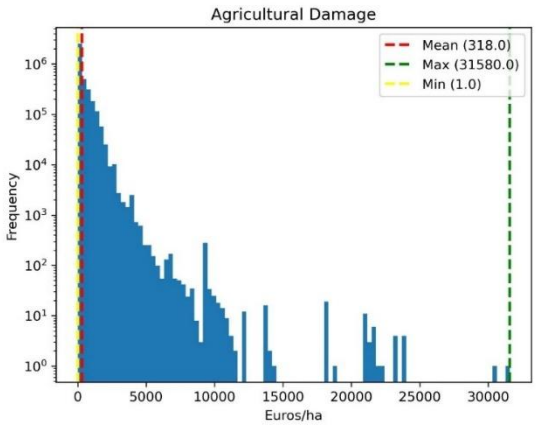
Copyright © FirEURisk Consortium. All rights reserved.

3.4. Vulnerability products

3.4.1. Ecosystem services, ESva

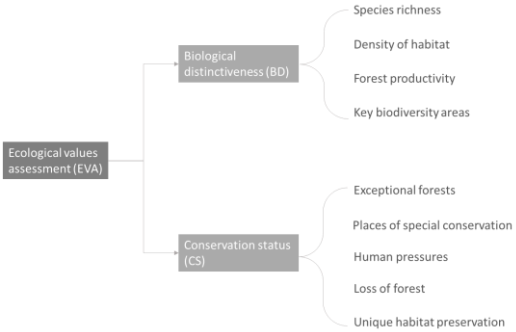
Description	This product estimates the economic values of expected damages by wildfires for the European Territory assessed for different assets (some provisioning services such as agricultural and forestry goods; regulating ecosystem services such as pollination, carbon sequestration and soil erosion; and manufactured capital such as properties). Values are mapped and reported at a resolution of 1 km^2 for the year 2021.
Type & format	Geospatial (.tif) and document
Units	Euros per hectare
Update Frequency	To be decided
Temporal coverage	2021
Spatial resolution	1km^2
Methodology	The approach used for the assessment of the potential damage of wildfires is based on the correction of the economic value of natural capital by a loss coefficient (ranging 0 to 1), function of the intensity of fire [12] and the time of recovery of the asset [13]. Coefficients of loss are measured in Spanish Mediterranean forests for timber [14], carbon sequestration [15] and soil erosion [16] and adapted to other assets (agricultural perennial crops) according to the judgement of the research team. Economic values of natural capital (agricultural and forestry assets) are assessed by market-based approach. The values of regulating ecosystem services are taken by the INCA project [17], [18], while the value of properties is made by correcting national prices provided by *Numbeo* by the local GDP per capita [19]. We derived maps of damage for timber, livestock, fruit trees, olive groves and vineyards, assuming that the value of natural capital asset is lost for the time necessary for a specific asset to recover from wildfires. Recovery time for trees is variable from 50 to 200 years [18]. We have assumed 50 years as a reasonable time to assess the damage of timber. There is no information in the literature about the recovery time of fruit trees, olive groves and vineyards, therefore the choice of recovery time (5 years) was guided only by judgement of the research team. Recovery time for the damage of ecosystem services such as soil retention are measured assuming values proposed by Milazzo et al. (2022) [20], ranging from 6 to 20 years. These damages are assessed as the present value of the future losses, assumed constant until the natural asset has fully recovered [13]. A social discount rate of 3.5% is used. Values of carbon sequestration are generated with an approach that considers the recovery of vegetation following a logistic curve [1]. The parameters of the logistic curve are not empirically estimated, nor deduced from the literature, but proposed by the research team to test their sensitivity on the expected damage. Damage to properties is assessed by correcting the property values by a coefficient of loss, which is function of the material of the property (concrete or wood) and the intensity of fire. These coefficients of loss are proposed by the research team but not yet validated.

Copyright © FirEUrisk Consortium. All rights reserved.

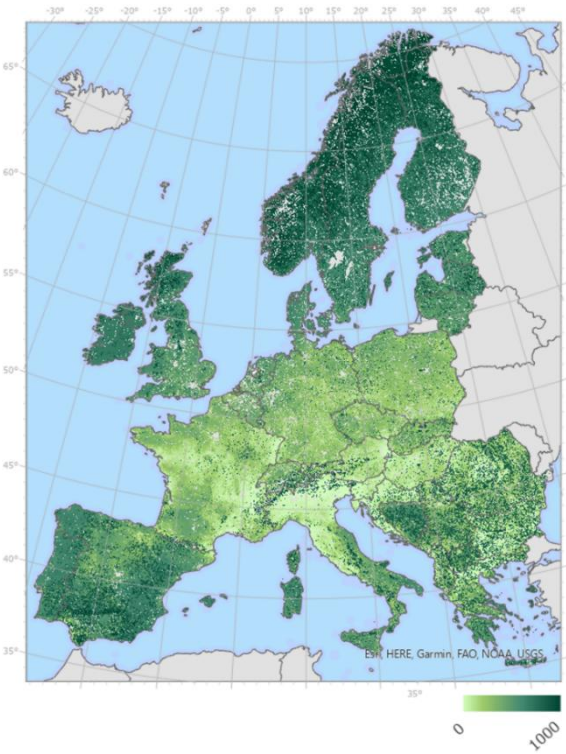
Contact	Simone Martino, HUTTON: simone.martino@hutton.ac.uk Clara Ochoa, UAH: mclara.ochoa@uah.es
Overview	 *a) Map of the total damage of the agroforestry values.*  *b) Histogram of the distribution of the damages reported in (a).* The map proposed (a) refers to the total damage of several natural capital assets (timber, livestock, fruit trees, olive groves, vineyards). Values are expressed in 2021 euros per hectare. The histogram of these values (a) shows that the average damage is just a few euros per hectare, however the distribution of these values is skewed to the right with just a few pixels reporting vales from 20 to 30 thousand euros per hectare. The map shows that areas of particular damage are central Europe, the Alps, the Apennines, the Pyrenees, northern Portugal, Southern Spain and the Balkan peninsula.

Copyright © FirEUrisk Consortium. All rights reserved.

3.4.2. Ecological values, EVa

Description	The product is a raster TIFF layer with a spatial resolution of 1 km, providing current ecological value data across Europe. This dataset offers up-to-date information, making it suitable for contemporary environmental analyses and applications.
Type & format	Geospatial (.tif)
Units	0-1000, from low ecological values to high ecological values
Update Frequency	10 years
Temporal coverage	2020
Spatial resolution	1km
Methodology	The methodology used for ecological values assessment (EVA) is based on characterising the ecosystems' biological distinctiveness (BD) and conservation status (CS) based on the methodology scheme proposed by Dinerstein et al., (1995) [21]. We stated that ecosystems hosting high taxonomic richness [22] or rare plant communities, or habitats of endangered species highly contribute to their value through their enhanced functioning. The destruction or degradation of these valued ecological components, notably by fires, can have long-term implications for ecosystem health and conservation [23].  *a) Components of the estimation of ecological values.* The previously described indicators (from BD and CS) were introduced in the Principal Components Analyses (PCA) model [24], taking the positive direction for values close to 1000 and negative for those close to 0. Species richness, forest productivity, density of habitat, key biodiversity areas, exceptional forest, unique habitat preservation and places of special conservation conserve the original direction. In contrast, the human pressure and loss of forest indicators inverse the direction, taking values close to 1000 where human pressure and loss of forest values were low. Regarding the previous explanation, we selected the first PCA because it represents the synergies between conservation status and biological distinctiveness. For example, zones with fewer roads and railways and a loss of forest cover conserve better ecological values.
Contact	Emilio Chuvieco, UAH: emilio.chuvieco@uah.es
Publication	[25] Arrogante-Funes, F., Mouillot, F., Moreira, B., Aguado, I., & Chuvieco, E. (2024). Mapping and assessment of ecological vulnerability to wildfires in Europe. Fire Ecology, 20(1), 98. https://doi.org/10.1186/s42408-024-00321-8

Copyright © FirEURisk Consortium. All rights reserved.

Overview	 *b) Map of ecological value assessment (EVA) in Europe, scaled from 0 (low value) to 1000 (maximum value). Zones with 0 values were related to areas not considered in this study, such as crops or urban areas.*

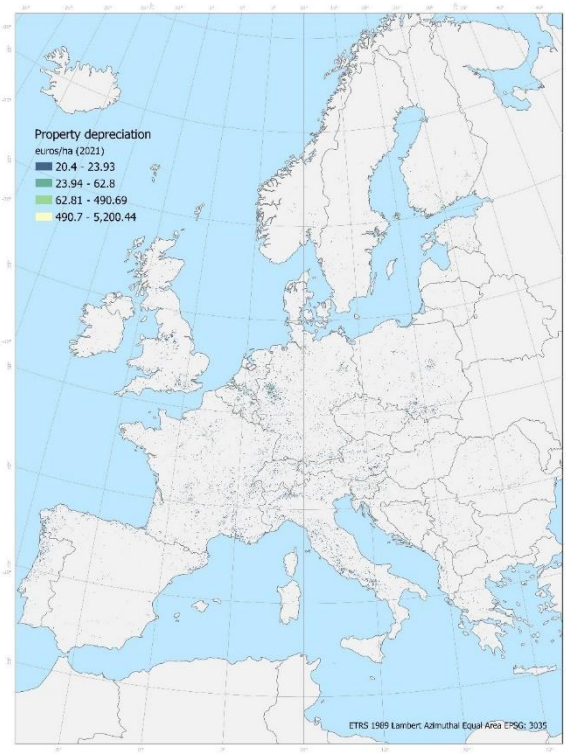
Copyright © FirEURisk Consortium. All rights reserved.

3.4.3. Houses value, HV

Description	This cartographic product represents estimated property values across Europe in €/ha (2021 currency), integrating national property prices with local economic data. Given the lack of detailed property value databases, the estimation is based on a national-scale model, assuming a linear relationship between property value and regional income. The map is built using Numbeo's national property prices (outside city centres), adjusted with EUROSTAT GDP per capita ratios (2019) at national and NUTS2 levels. To refine spatial distribution, a 2015 gridded GDP dataset [19] was applied. Additionally, potential fire damage to properties is assessed using loss coefficients based on construction material (concrete or wood) and fire intensity, though these coefficients remain unvalidated. The product provides a spatialized representation of property values and potential economic losses due to fire across Europe.
Type & format	Geospatial (.tif) and document (.txt, .doc. .pdf)
Units	Euros per hectare
Update Frequency	Not decided yet
Temporal coverage	2021
Spatial resolution	1 km^2
Methodology	The value of properties is made by correcting national prices provided by Numbeo by the local GDP per capita [19]. Details are provided by Martino et al. (2023). The property values are expressed in €/ha (2021 currency). Due to limited property data, values were estimated at a national scale using GDP maps, assuming a linear relation between property value and regional income. The baseline was the national average property value outside city centres from Numbeo website, adjusted using EUROSTAT GDP per capita ratios (2019) at both national and NUTS2 levels. To map the values of properties in Europe, a 2015 GDP dataset [19] was used, adjusting local GDP by national GDP and applying spatial corrections. Numbeo values, originally in dollars, were converted to euros using 2021 exchange rates (0.84). Damage to properties is assessed by correcting the property values by a coefficient of loss, which is function of the material of the property (concrete or wood) and the intensity of fire. These coefficients of loss are proposed by the research team but not yet validated.
Contact	Simone Martino, HUTTON: simone.martino@hutton.ac.uk Clara Ochoa, UAH: mclara.ochoa@uah.es

Copyright © FirEUrisk Consortium. All rights reserved.

Overview



a) Map of the total damage of the property values.

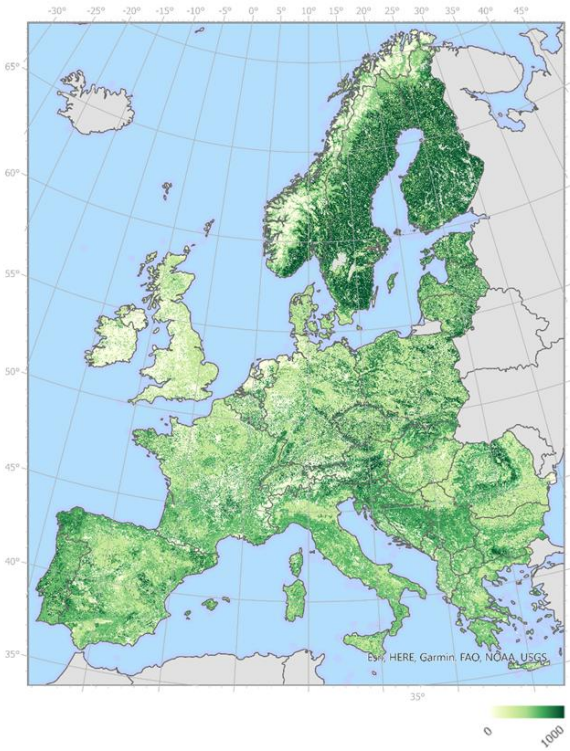
Copyright © FirEURisk Consortium. All rights reserved.

3.4.4. Coping capacity, CC

Description	Ecosystem Coping Capacity (CC) refers to the ability of the vegetation component of the ecosystem (dominant tree species present within pixels referenced as forests, or vegetation types for shrubland, grasslands and croplands) to resist a fire event. Values vary between 0 for killed individuals to 1000 for fully resistant species not affected by the fire.
Type & format	Geospatial (.tif) and document
Units	Fraction (0-1000)
Update Frequency	No
Estimated Accuracy	100 %
Spatial resolution	1 km
Methodology	The EU scale coping capacity at 1km resolution, was generated from Corine Land cover identifying forests, shrublands, grasslands, croplands and other areas (non-burnable), potential tree species distribution, and their functional traits acknowledged as contributing to fire survival (bark thickness, Tree height, basal crown height) [26]. Pixel's coping capacity resulted from the specific coping capacities of species present in the pixel. Grasslands, croplands and shrublands/heathlands were assumed as fully burned (CC=0) during fire events, Species coping capacity was finally linearly reduced according to higher fire intensity.
Contact	Florent Mouillot, IRD: florent.mouillot@ird.fr
Publication	[25] Arrogante-Funes, F., Mouillot, F., Moreira, B., Aguado, I., & Chuvieco, E. (2024). Mapping and assessment of ecological vulnerability to wildfires in Europe. Fire Ecology, 20(1), 98. https://doi.org/10.1186/s42408-024-00321-8

Copyright © FirEURisk Consortium. All rights reserved.

Overview



a) Map of the ecosystems' Coping Capacity to fire over Europe (0 non-resistance, 1000 high resistance).

Copyright © FirEURisk Consortium. All rights reserved.

3.4.5. Recovery time, RT

Description	Ecosystem recovery time (RT) refers to the time (in years) needed for the vegetation component of the ecosystem (dominant tree species present within pixels referenced as forests, or vegetation types for shrubland, grasslands and croplands) to fully recover from a fire event. RT includes both the recovery starting time (RST) and growth rate (GR). RST is the time needed for a species to get the sufficient seed bank to start germination and grow and can be slightly negative for species resprouting from the basal root system to highly negative for species resprouting from apical buds. RST was locally modified with management strategies and climate. GR was derived from standard forest growth models locally modified with climate.
Type & format	Geospatial (.tif)
Units	Years
Update Frequency	No
Estimated Accuracy	5
Temporal coverage	Not applicable
Spatial resolution	1 km
Methodology	The EU scale recovery time (RT) at 1km resolution, was generated from CORINE Land Cover identifying forests, shrublands, grasslands, croplands and other areas (non-burnable), potential tree species distribution, and their functional traits related to post-fire regeneration strategy and growth rate. RT was decomposed into regeneration starting time (RST) and growth rate (GR). For RST, we collected information on tree species vegetative (resprouting) or seedling emergence (serotiny, seed dispersal) response strategies [27]. We attributed an RST value of -25 years for fire-tolerant species regenerating from trunk buds and -10 years for fire-tolerant species resprouting from belowground material. For species regenerating from the seed bank surviving the fire, we attributed an RST value of 0. Finally, for species without resprouting ability nor post-fire germination from the seed bank, we considered a colonisation delay (0 to 20 years) as the time needed for seeds to be dispersed from neighbouring unaffected ecosystems. Dispersal efficiency was related to seed mass, dispersal strategies and maximum distances [28]. For species carrying multiple strategies, we kept the lowest RST between the strategies. RST was locally modified by climate, soil erosion, forest management potentialities, and topography. For GR, we used each species' yearly growth rate (GR, m.year-1) and maximum tree height (THMAX, m) from forest growth models [29] to derive the Relative Growth Rate RGR (%HMAX.year-1), and derive the time needed for a species to reach its maximum height (RT in years = 1/RGR). GR was locally modified by environmental constraints of Mean Annual Temperature, Mean Annual Precipitation and Soil available water Capacity.
Contact	Florent Mouillot, IRD: florent.mouillot@ird.fr

Copyright © FirEURisk Consortium. All rights reserved.

Publication	[25] Arrogante-Funes, F., Mouillot, F., Moreira, B., Aguado, I., & Chuvieco, E. (2024). Mapping and assessment of ecological vulnerability to wildfires in Europe. Fire Ecology, 20(1), 98. https://doi.org/10.1186/s42408-024-00321-8
Overview	 *a) Map of Recovery Time (in years after fire) over Europe*

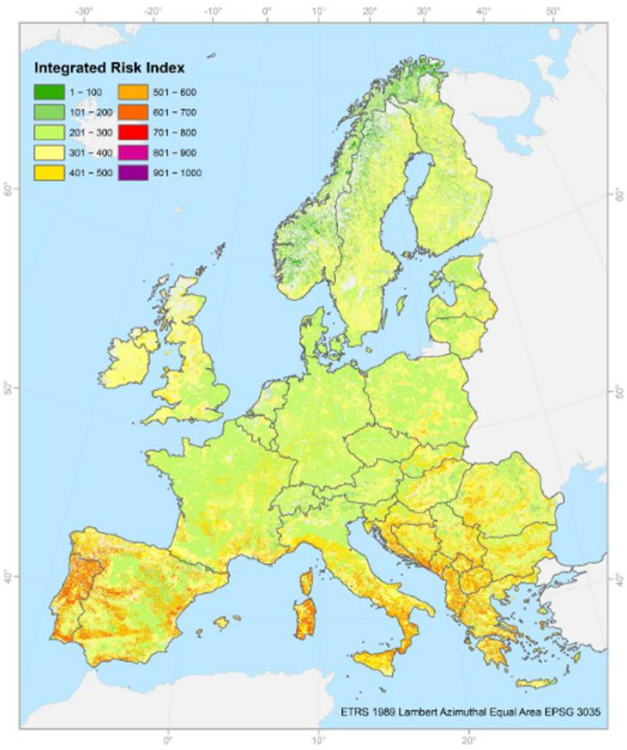
Copyright © FirEURisk Consortium. All rights reserved.

3.5. Risk assessment product

3.5.1. Integrated fire Risk Index, IRI

<table>
<tr><td>Description</td><td>Includes the different components of fire risk developed within the project, integrating Danger, Exposure and Vulnerabilty.</td></tr>
<tr><td>Type & format</td><td>Geospatial (.tif)</td></tr>
<tr><td>Units</td><td>Probabilty scale 0 to 1000</td></tr>
<tr><td>Update Frequency</td><td>Daily</td></tr>
<tr><td>Estimated Accuracy</td><td>Unknown</td></tr>
<tr><td>Temporal coverage</td><td>Tested in the summer of 2024</td></tr>
<tr><td>Spatial resolution</td><td>1 km^2</td></tr>
<tr><td>Methodology</td><td>The product integrates the different components of risk developed within FirEUrisk to give a synthetic view of fire risk conditions for a specific moment and area. The input data includes static data (human ignition, exposure…) and dynamic components (weather conditions, fuel moisture…). The table below includes a list of inputs. The overview figure below shows a graphical representation of the different components of risk considered in FirEUrisk. The Inputs to compute the Integrated Risk Index, listed below.
<table>
<tr><th>Variable</th><th>Units</th><th>Sources</th></tr>
<tr><td>TP, Temperature</td><td>º C</td><td>DWD-ICON7 data</td></tr>
<tr><td>Pp, Precipitation</td><td>mm</td><td>DWD-ICON7 data</td></tr>
<tr><td>WS, Wind speed</td><td>m/s</td><td>DWD-ICON7 data</td></tr>
<tr><td>RH, Relative Humidity</td><td>%</td><td>DWD-ICON7 data</td></tr>
<tr><td>FT, Fuel types</td><td>Fuel classes</td><td>FirEUrisk fuel map</td></tr>
<tr><td>PNI, Probability of natural ignition</td><td>0/1000</td><td>Weather data and lightning</td></tr>
<tr><td>PHI, Probability of human ignition</td><td>0/1000</td><td>Human and biophysical factors</td></tr>
<tr><td>LFMC, Live fuel moisture content</td><td>% DW</td><td>Satellite data</td></tr>
<tr><td>E, Exposure</td><td>0, 0.8, 1</td><td>WUI, land cover</td></tr>
<tr><td>SEV, Value of Houses and Infrastructures</td><td>€/ha</td><td>Statistics</td></tr>
<tr><td>CL, Climatic regions</td><td>1-2 / No-Yes Med</td><td>Proxy of building materials</td></tr>
<tr><td>EST, Ecosystem service values.</td><td>€/ha/year</td><td>Statistics</td></tr>
<tr><td>EVa, Ecological values</td><td>0/1000</td><td>Cartographic & vegetation databases</td></tr>
<tr><td>LEV, Potential loss of Ecological values</td><td>0/1000</td><td>Coping capacity, resistance</td></tr>
<tr><td>RT, Regeneration time</td><td>years</td><td>Several species</td></tr>
</table>
The integration of the different components was based on quantitative weighting, considering the relative importance of each component in terms of extreme fire risk assessment. The integrated risk index (IRI), was computed by combining the Danger (D), Exposure (E) and Vulnerability (V), with the following formula:
IRI = (0.6*D + 0.4*V)*E
Danger was derived from Probability of Ignition and Propagation Potential. Vulnerability was derived from estimated social damages (including housing and ecosystem services) and ecological damages (including the coping capacity of plants and their recovery potential), by estimating the reduction of values (both ecosystem services and ecological values) that would occur in case the area is burned. The conditions of that burning depend on propagation estimates, considering weather conditions and fuel characteristics,</td></tr>
</table>

Copyright © FirEURisk Consortium. All rights reserved.

	particularly on Fire Line Intensity and Flame Length, which affect the degree of estimated post-fire severity. Exposure was estimated by considering burnable cover (weight 0.8), with an additional weight for those areas with WUI (weight 1), and 0 for the unburnable areas.
Contact	Emilio Chuvieco, UAH: emilio.chuvieco@uah.es
Publication	[1] Chuvieco, E., Yebra, M., Martino, S., Thonicke, K., Gómez-Giménez, M., San-Miguel, J., Oom, D., Ramona Velea, Florent Mouillot, Juan R. Molina, Ana I. Miranda, Diogo Lopes, Michele Salis, Marin Bugaric, Mikhail Sofiev, Evgeny Kadantsev, Ioannis Gitas, Dimitris Stavrakoudis, George Eftychidis, Bar-Massada, A., Alex Neidermeier, Valerio Pampanoni, Pettinari, M.L., Arrogante, F., Ochoa, C., Moreira, B., & Viegas, D. (2023). Towards an integrated approach to wildfire risk assessment: when, where, what and how the landscapes may burn. Fire, 6, 215, doi210.3390/fire6050215.
Overview	 *Example of IRI values for the extreme fire weather scenario.*

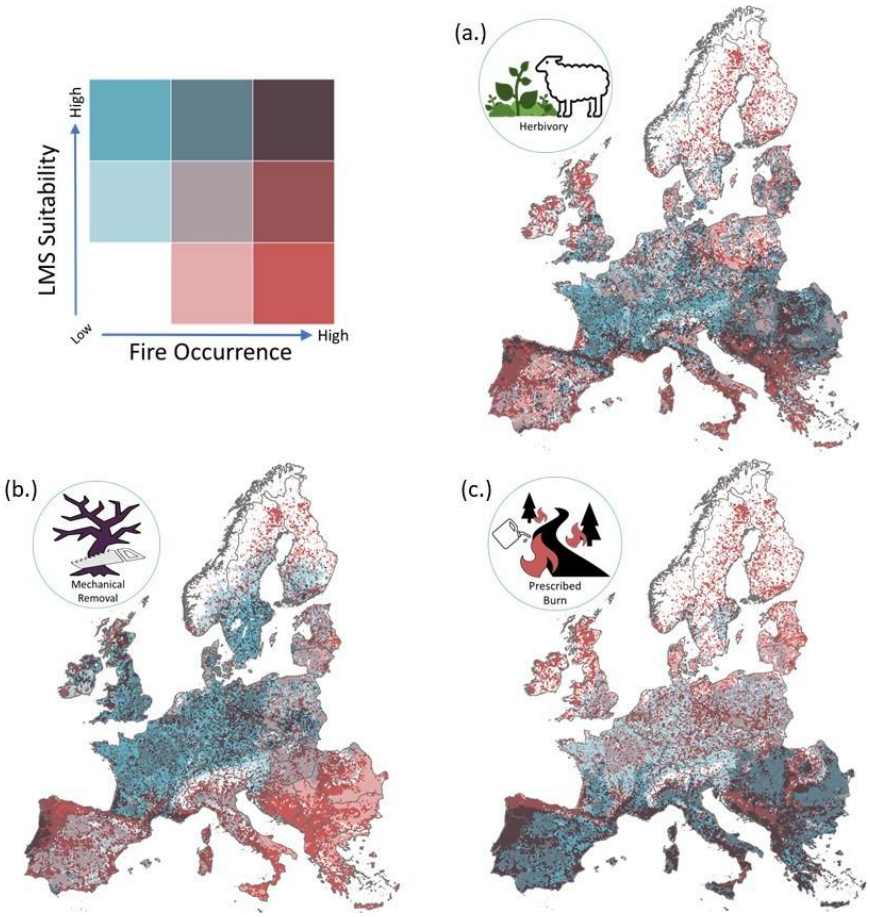
Copyright © FirEUrisk Consortium. All rights reserved.

3.6. Risk mitigation and reduction products

3.6.1. Maps of suitable areas for Land Management Strategy

Description	This product includes a set of maps which summarize suitable areas for the use of three relevant land management strategies (FRLMS) aimed to reduce fuel cover and fuel load —herbivory, mechanical removal, and prescribed burn—at the landscape-scale in Europe, under the risk reduction activity, oriented to the components of Danger -> Propagation -> Fuels, fire risk component of the integrated project strategy. Full details on the biophysical, socioeconomic, and environmental factors which can contribute to the uptake and success of the FRLMS, including a summary of the methodology; decision trees for choosing suitable FRLMS; maps of FRLMS-suitable areas (as in Neidermeier et al., 2023 [30]; and maps of hot-spots of ecosystem function (here used as an umbrella term which includes biodiversity and carbon storage) and wildfire occurrence (Neidermeier et al., 2024, in review) in Europe can be found in Deliverable 2.4 "Guidelines for Land Management Strategies: Applicability, socioeconomics and environmental concerns".
Type & format	Geospatial (.tif)
Units	Suitability of each FRLMS per km^2
Update Frequency	Not Applicable
Estimated Accuracy	Not Applicable
Spatial resolution	1 km^2
Methodology	A semi-systematic literature review identified constraints and opportunities of adopting different FRLMS to reduce wildfire risk in Europe. Although more than ten strategies were identified, we narrowed our study to those most frequently referenced in the literature to provide the broadest evidence base; selecting those which targeted fuels and biomass reduction by way of land management specifically (instead of land-use changes, e.g., replacement of species, construction of vegetation mosaics or fire breaks). Spatially explicit suitability factors for the adoption of the three FRLMS were defined based on the results. In summary, the suitability map for herbivory encompasses areas which (1) have greater presence or diversity of domesticated or wild ungulate grazers or browsers; (2) have greater accessibility to livestock and can allow for transportation of livestock products; (3) have a greater share of suitable pasture. The suitability for mechanical fuel removal, including pruning, silvicultural activities, and extraction for industry, was represented by areas with (1) greater forest biomass availability; (2) greater proximity to documented biomass conversion powerplants; (3) greater accessibility for transportation of raw materials and products; and (4) were located on suitable degrees of slope for machine and labor access. Finally, suitability for prescribed burning reflects areas with (1) a greater number of days with safe and effective prescribed burn conditions, considering the ecological impact as well ('prescribed burn days,' or PBD); (2) greater accessibility to allow for transport of equipment and labour; and (3) sufficient distance from major settlements (which may be adverse to resulting smoke). We used a static Wildfire Danger by Thermal Anomaly (WDTA) dataset, developed by EFFIS (https://effis.jrc.ec.europa.eu/apps/fire.risk.viewer/), to prioritize the results by areas most affected by wildfire in Europe. The full methodology and results of the literature review can be found in FirEUrisk

Copyright © FirEUrisk Consortium. All rights reserved.

	Deliverable 2.4 ("Guidelines for Land Management Strategies: Applicability, socioeconomics and environmental concerns") and in Neidermeier et al, 2023 [31].
Contact	Alex Neidermeier, VUA: a.neidermeier@vu.nl
Publication	[31] Neidermeier, A.N., Zagaria, C., Pampanoni, V., West, T.A.P., & Verburg, P.H. (2023). Mapping opportunities for wildfire hazard reduction in Europe through targeted land management strategies. *Journal of Environmental Management 346*. **Dataset:** [32] Neidermeier, A. (2023). Data for Mapping opportunities for the use of land management strategies to address fire risk in Europe (Version 1) [Dataset]. DataverseNL. https://doi.org/10.34894/JQS5MD
Overview	 *Bivariate choropleth maps of suitability of (a.) herbivory, (b.) mechanical fuel removal, and (c.) prescribed burn which overlap with areas of differing fire occurrence in Europe. Areas in white had low FRLMS suitability and low fire occurrence.*

Copyright © FirEUrisk Consortium. All rights reserved.

3.6.2. Handbook with guidelines to face extreme fires, and fires in Wildland-Urban Interface areas

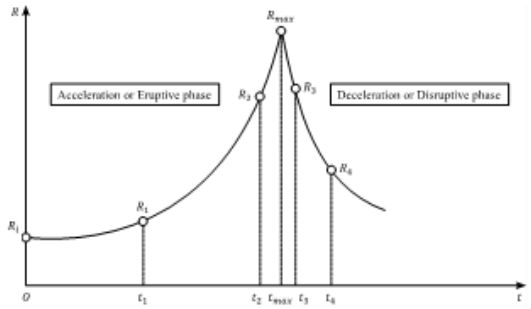
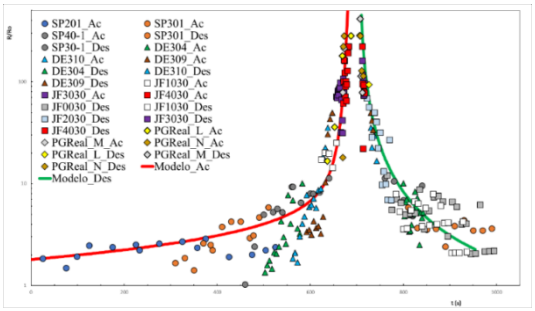
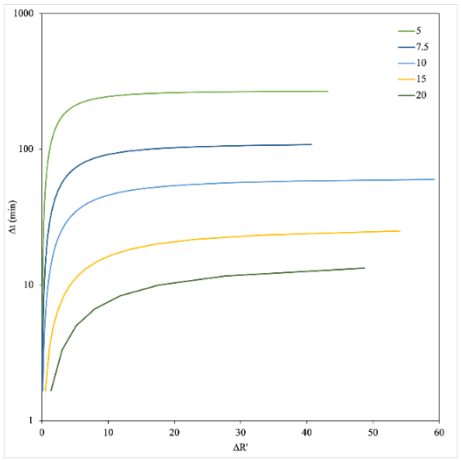
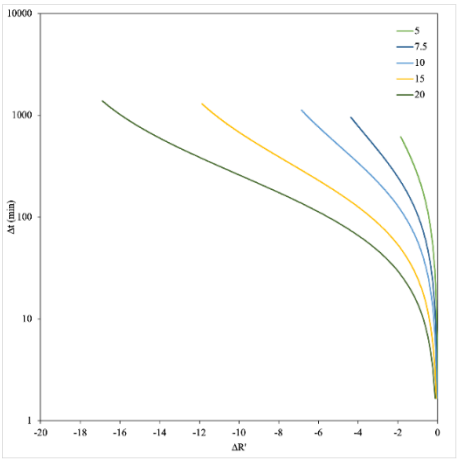
Description	This product in a form of curriculum provides firefighters and managers an appropriate understanding of extreme fire behaviour and Wildland-Urban Interface (WUI) challenges. This Product considers the evolution of fire risk and the transferability of strategies used in Mediterranean countries to fight fires in Northern/higher elevation contexts.
Type & format	Guidelines product in 6 different languages (English, French, Portuguese, Romanian, Croatian, and Italian).
Update Frequency	Years
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. Data sources available: list of 170 reference papers cited at the end.
Contact	Sebastien Lahaye, SAFE CLUSTER: sebastien.lahaye@safecluster.com
Publication	(Publication In Process)
Overview	

Copyright © FirEURisk Consortium. All rights reserved.

3.6.4. Fire behaviour predictive models

Description	The product on predictive models for extreme fire behaviour (EFB) is based on historical data on fire occurrence, laboratory and field tests in conditions that lead to EFB. Product provides methods to predict temporal variations of the rate of spread (ROS) of the head fire to allow an early warning to the authorities and population in operations
Type & format	Semi-empirical models, tables and graphs
Units	Rate of spread variation (cm/s; m/min; km/h) Time delay for ROS Variation (minutes)
Update Frequency	1 to 10 hours
Estimated Accuracy	ROS variation 1 km/h Time delay 10 minutes
Temporal coverage	Minutes to hours
Spatial resolution	> 1ha (30m)
Methodology	Fire behaviour modelling based on Rothermel model [33], [34] incorporated in fire spread simulators like Farsite and FireStation that were used extensively in the project. Given the limitations of this model in FirEUrisk we developed original research to analyse the dynamic behaviour of fires that leads to conditions of extreme fire behaviour (EFB). The product is based on the analysis of the interaction between the fire and the surrounding atmosphere that causes an intermittent or oscillatory temporal variation of the head fire rate of spread (ROS) (cf. Viegas et al. 2021, 2022 [35], [36]). It was found that the head fire spreads in a succession of accelerations and decelerations which in some circumstances can reach very high values of the ROS, corresponding to fireline intensities above the capacity of suppression. A semi empirical analytical model to predict the variation of the ROS during the acceleration and deceleration phase was developed and tested using data from laboratory and field scale experiments and real fires. The model can predict the time required for the fire to modify its ROS between two given values either during acceleration or deceleration. This knowledge goes beyond the state of the art and provides an information of great practical value to deploy fire suppression forces in operations with increased efficiency and safety. The model uses the non-dimensional parameters: ROS $R'=R/R_o$ Time $t'=t/t_o$ In order to use the model, it is required to know the basic rate of spread R_o (m/min) of the fire in the given fuel bed and the residence t_o (sec) of the combustion reaction of the fuel bed. The initial values of the ROS can be obtained using Rothermel model or other sources; the maximum values of the ROS have to be estimated, based on the literature. Typical values of all parameters for a wide range of practical applications, derived from real

Copyright © FirEUrisk Consortium. All rights reserved.

	fires, are given in the reference. Detailed description of algorithm of calculation and data sources available here: Viegas et al. (2024)[6].
Contact	Domingos Xavier Viegas, ADAI: xavier.viegas@dem.uc.pt
Publication	D. X. Viegas, C. Ribeiro, L.M. Ribeiro, M. Almeida, T. Rodrigues, T.F. Barbosa. (2024). Analytical Model to Predict the Dynamic Self-induced Acceleration and Deceleration of a Head Fire. (*Manuscript submitted for publication*).
Overview	*a*  *b*  *Definition of the acceleration and deceleration phases of a head fire and comparison between the model and the measurements.* *c*  *d*  *c) Time delay required for the positive variation of the non-dimensional ROS of the head fire (R'_2-R'_1) for different values of R'_1. d) Time delay required for the negative variation of the non-dimensional ROS of the head fire (R'_4-R'_3) for different values of R'_4.*

[6] Manuscript submitted for publication

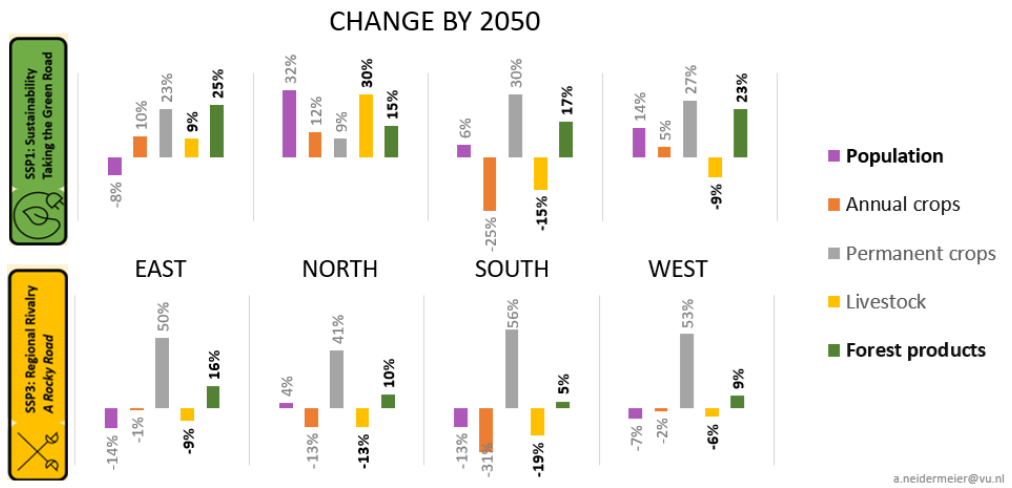
Copyright © FirEURisk Consortium. All rights reserved.

3.7. Risk adaptation product

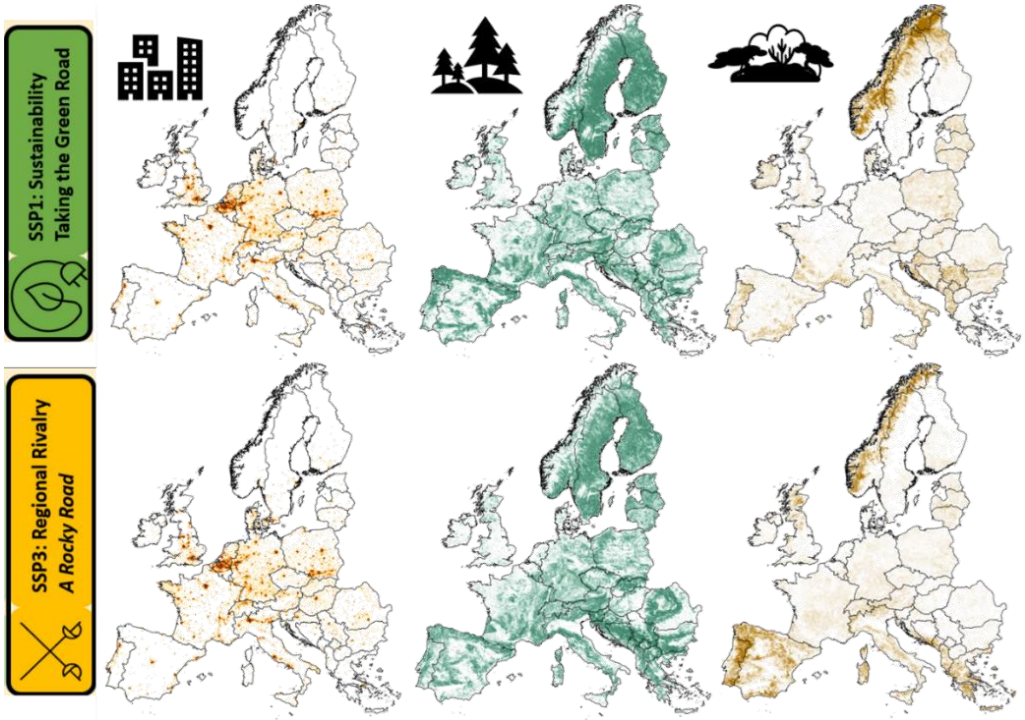
3.7.1. Continental land-use change scenarios and stylised fuel management scenarios

Description	For the report "Continental land-use change scenarios and stylised fuel management scenarios for the 21st century", VUA created a blended land use dataset spanning from 1960 to 2050 at a 9-km^2 resolution and a consolidated legend with seven land use classes. This dataset is a key input for the Dynamic Global Vegetation Models (DGVMs) which have been coupled with fire spread models (e.g., SPITFIRE) to explore how burned area, carbon emissions, and vegetation (amongst other variables) may respond to several global socioeconomic and climate scenarios. The blended land use dataset was developed using historic land use from 1960-2015 using HILDA+ [37] and simulated land use to 2050 using the CLUMondo model The blended product incorporating 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 simulate future fire regimes.
Type & format	Geospatial (.tif)
Units	Land cover classes
Update Frequency	Static
Temporal coverage	1960-2050 (decadal)
Spatial resolution	9 km
Methodology	Historic baseline data developed in HILDA+ combines several open data streams (remote sensing, reconstructions and statistics) to estimate historic land use change at 1-km^2. The CLUMondo future scenarios were generated by dynamically allocating anticipated resource demands to European areas deemed suitable. The demands given to CLUMondo are based on outputs from global, macroeconomic GLOBIOM model output for Shared Socioeconomic Pathways (SSP) 1, "Sustainability", and SSP3, "Regional rivalry" (Fig. 1). Europe is split and run as four separate regions in CLUMondo-North, South, East, and West with different demands within each region. While the time series is based on a 1-km resolution, we made a conversion in aggregating the data to a 9-km resolution and an aggregated land cover class legend to match that used natively in the DGVMs.
Contact	Alex Neidermeier, VUA: a.neidermeier@vu.nl
Publication	**Dataset:** [38] Neidermeier, A. (2022). Continental Land Use Change scenarios and stylized fuel management scenarios (Version 1) [Dataset]. DataverseNL. https://doi.org/10.34894/ALZTYS
Overview	Under SSP1, population, permanent crops, and forest product demands increase overall. In SSP3, demand for permanent crops increases, but all others decrease. Comparing SSP results for 2050 (b), large differences are seen between regions. The decrease in forest cover in Eastern Europe seen in SSP3 is striking, as are the increases in shrublands in Southern Europe in SSP3.

Copyright © FirEURisk Consortium. All rights reserved.



a) Percent change in demands by 2050 used to simulate future land use scenarios for population, annual crops, permanent crops, livestock, and forest products for each region of Europe (East, North, South, West) under SSP scenarios 1 (top) and 3 (bottom).

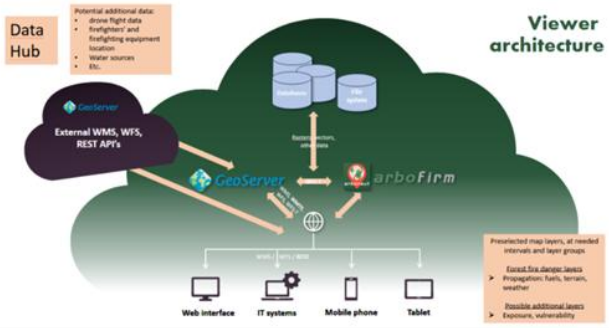
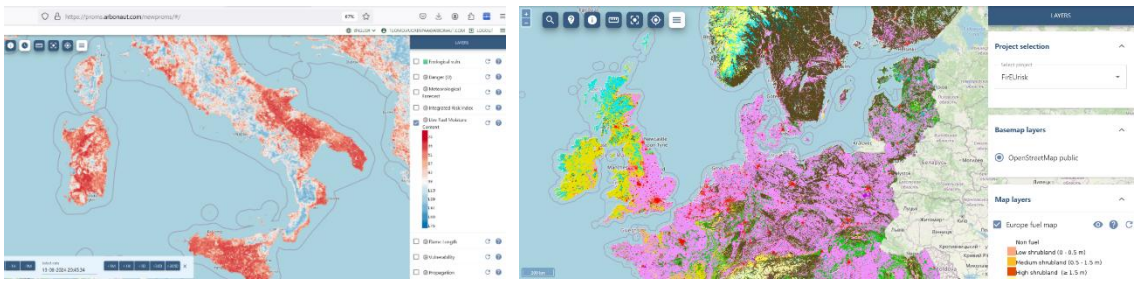


b) Simulated land cover in SSP 1 & 3 in 2050 for cities (left), forests (centre), and shrublands (right).

Copyright © FirEURisk Consortium. All rights reserved.

3.8. Instrumental products

3.8.1. FirEURisk Open Viewer

Description	The tool allows visualising 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.
Type & format	Software / Web application / Mobile application
Methodology	The Viewer is composed of a GIS web interface and supporting backend services. The web application is compatible with the most widely used browsers across Windows, Linux, and iOS operating systems. Additionally, a separate Android mobile version is available. However, for FirEURisk user accounts, a mobile application has not been released, as no clear use cases have been identified to justify its development and deployment. The Viewer is composed of a GIS web interface and supporting backend services. The web application is compatible with the most widely used browsers across Windows, Linux, and iOS operating systems. Additionally, a separate Android mobile version is available. However, for FirEURisk user accounts, a mobile application has not been released, as no clear use cases have been identified to justify its development and deployment.  *Overview of Viewer's architecture* The PostGIS database has been enhanced with additional GIS data, organised into separate tables within the central database, hosted by ARBONAUT. The data are displayed as distinct map layers within the application.
Contact	Tuomo Vuorenpää, Arbonaut: tuomo.vuorenpaa@arbonaut.com
Website	https://proms.arbonaut.com/newproms/
Overview	

Copyright © FirEURisk Consortium. All rights reserved.

3.8.2. Laws, regulations, plans and programmes on fire prevention, preparadeness and resilience

Description	This product consists on a conceptual framework that incorporate all the project's findings, models, systems and results, integrating them and aiming at proposing an integrated strategy to cope with all phases of fire risk management.
Type & format	Document (.docx, .xls)
Update Frequency	1 year
Temporal coverage	6 months
Methodology	The methodology is of an SSH nature as it aims to address, from a comparative point of view, the several policies legislations of the partner States to the project on fire prevention, preparedness and resilience, in what regards their impact on People / Forest/ Technology ad Governance. This product will be therefore, a Model of a Conceptual Framework that will allow for an integrated analysis of the most relevant dimensions of policies and legislations on fire prevention preparedness and resilience. In each of its vectors of analysis (People, Forest, Technology and Governance) the vision of applicable policies and legislation; the principles applicable; the goals to be attained and the distribution of competences should be detailed, as the example of the product, referred to Portugal (and mostly to Law 82/2021 on the Integrated Management System of Rural Fires, the Legislation on territorial planning and civil protection) demonstrates. Besides schemes, similar to the one's shown before, each national report should have a 3 to 5 pages report explaining those schemes. The Model Conceptual Framework proposed should be filled in by all partners regarding their own policies and State legislations, therefore it has the same territorial scope as the project FirEUrisk itself.
Contact	Domingos Xavier Viegas, ADAI: xavier.viegas@dem.uc.pt
Overview	

Copyright © FirEUrisk Consortium. All rights reserved.

4. Portfolio of Regional Products for an Integrated Wildfire Risk Management Strategy

4.1. Summary of the portfolio

The **FirEUrisk Regional Products Portfolio** provides **twenty-three products**, tested and demonstrated in the five pilot sites, covering wildfire risk conditions in different biogeographic regions: **Mediterranean**, **Central-Eastern**, and **Northern Europe**. Pilot sites, comprise areas between 2,000 and 8,000 km^2; high-spatial resolution datasets were used throughout with a standardised target scale of 1 ha for all products, although data quality often allowed better resolutions which were welcomed by stakeholders. All regional geospatial products are publicly downloadable from FirEUrisk DatHub. Figure 13 below traces each regional product to the specific wildfire integration factor that contributes to resolve.

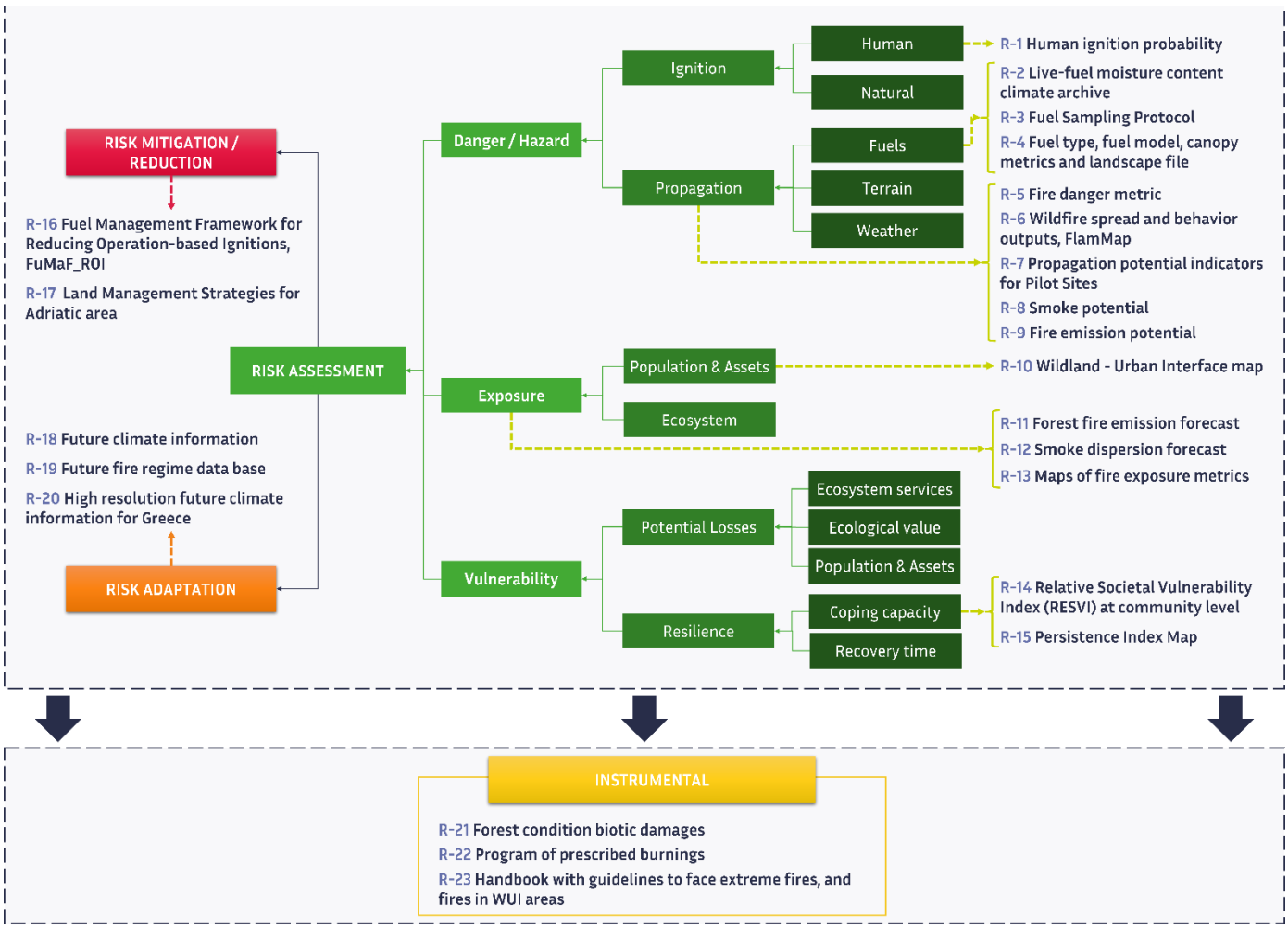


Figure 13. FirEUrisk Regional Products schema.

Copyright © FirEUrisk Consortium. All rights reserved.

Table 9 lists the **Regional Products** traced to the fire risk component, the producer, and the TRLs.

Table 9. FirEURisk Regional Products Portfolio

Id	FirEURisk Regional Products	Integration of fire risk components	Producer	TRL
R-1	Human ignition probability for Pilot Sites	Danger	UdL	TRL 3
R-2	Live-fuel moisture content climate archive	Danger	TUD	TRL 3
R-3	Fuel Sampling Protocol	Danger	CNR IBE	TRL 3
R-4	Fuel type, fuel model, canopy metrics and landscape file	Danger	UdL	TRL 5
R-5	Fire danger metric	Danger	UdL	TRL 4
R-6	Wildfire spread and behaviour, FlamMap	Danger	UdL	TRL 3
R-7	Propagation potential indicators for Pilot Sites, PP-PS	Danger	FESB SPLIT	TRL 3
R-8	Smoke potential	Danger	UAVR	TRL 4
R-9	Fire emission potential	Danger	UAVR	TRL 4
R-10	Wildland-Urban Interface map	Exposure	HU	TRL 8
R-11	Forest fire emission forecast	Exposure	UAVR	TRL 3
R-12	Smoke dispersion forecast	Exposure	UAVR	TRL 3
R-13	Maps of fire exposure metrics	Exposure	UAVR	TRL 8
R-14	Relative Societal Vulnerability Index (RESVI) at community level	Vulnerability	ISIG	TRL 3
R-15	Persistence Index Map	Vulnerability	UdL	TRL 3
R-16	Fuel Management Framework for Reducing Operation-based Ignitions, FuMaF_ROI	Mitigation	AUTH	TRL 7
R-17	Land Management Strategies for Adriatic area	Mitigation	FESB SPLIT	TRL 7
R-18	Future climate information	Adaptation	METEOGRID	TRL 5
R-19	Future fire regime database	Adaptation	PIK	TRL 5
R-20	High resolution future climate information for Greece	Adaptation	NCSR	TRL 4
R-21	Forest condition biotic damages	Instrumental	GMV	TRL 6
R-22	Program of prescribed burnings	Instrumental	CNR IBE	TRL 7
R-23	Handbook with guidelines to face extreme fires, and fires in Wildland-Urban Interface areas	Instrumental	FESB SPLIT	TRL 7

Copyright © FirEURisk Consortium. All rights reserved.

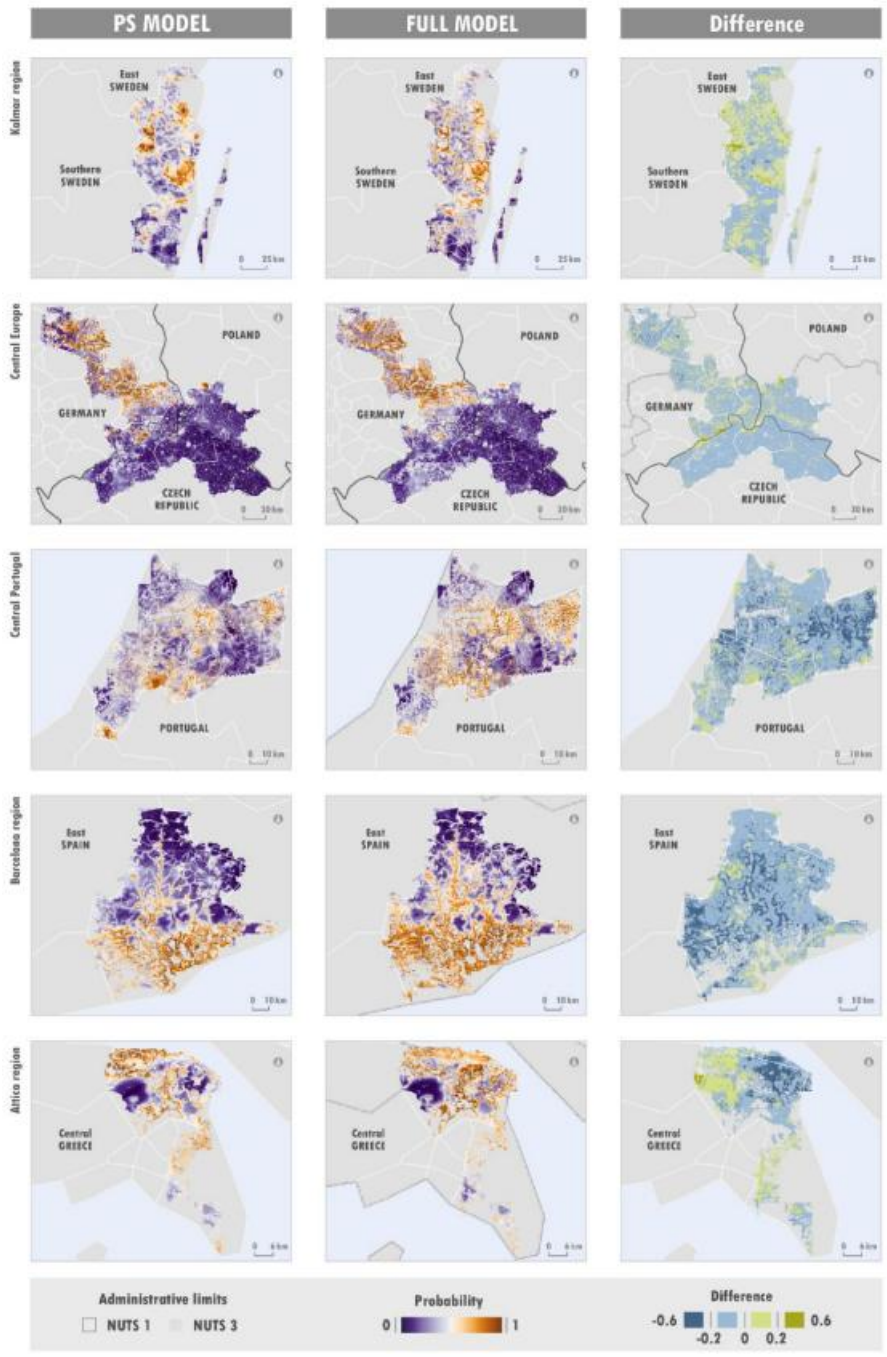
4.2. Danger or hazard products

4.2.1. Human ignition probability for Pilot Sites

Description	This product estimates the probability that a human caused fire ignites at the pilot site scale. The final output is a probabilistic raster map (scale 0 to 1).
Type & format	Geospatial (.tif) and model (.RData)
Units	Probability (%)
Update Frequency	Static
Estimated Accuracy	70-80%
Temporal coverage	For Pilot Site 2: 2008-2018; Pilot Site 3: 2001-2021; Pilot Site 4: 2008-2018; and Pilot Site 5:2017-2021.
Spatial resolution	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.
Contact	Maria Cristina Vega Garcia, UdL: cristina.vega@udl.cat
Publication	[39] Jiménez-Ruano, A., Mimbrero, M. R., Urdíroz, F. A., Sjöström, J., Marrs, C., Ribeiro, L. M., ... & Vega-García, C. (2023, June). Assessing human-caused wildfire ignition likelihood across Europe. In *2023 8th International Conference on Smart and Sustainable Technologies (SpliTech)* (pp. 1-6). IEEE. [40] Gelabert, P. J., Jiménez-Ruano, A., Ochoa, C., Alcasena, F., Sjöström, J., Marrs, C., Ribeiro, L. M., Palaiologou, P., Bentué Martínez, C., Chuvieco, E., Vega-Garcia, C., and Rodrigues, M.: Assessing human-caused wildfire ignition likelihood across Europe, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2025-143, 2025

Copyright © FirEURisk Consortium. All rights reserved.

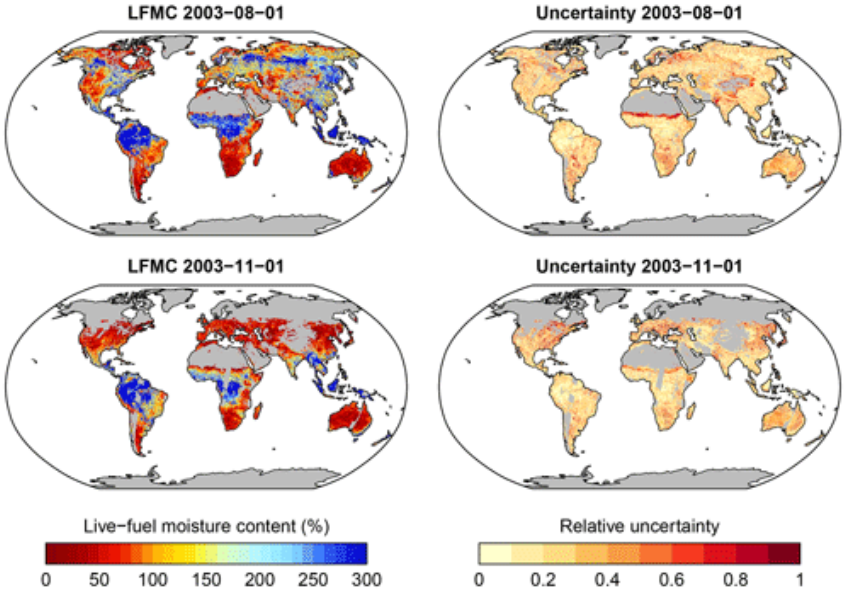
Overview



Spatial distribution of ignition probabilities predicted with PS models (left column) and the full model (middle columns), and difference in the prediction (right column). Source: Gelabert et al. (2025) [40]

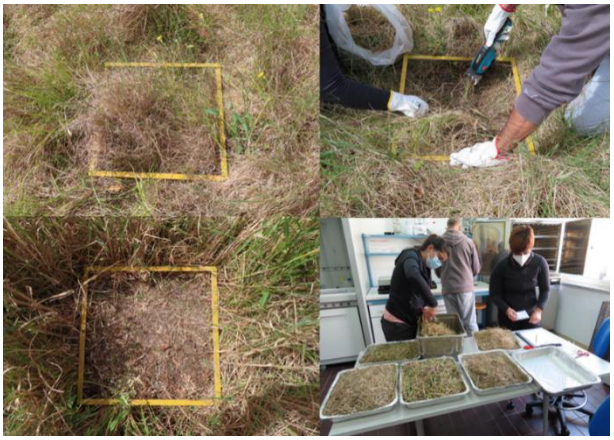
Copyright © FirEURisk Consortium. All rights reserved.

4.2.2. Live-fuel moisture content climate archive

Description	The product allows to investigate the long-term coarse-scale live-fuel moisture content derived from integrating passive microwave satellite observations of vegetation optical depth with in-situ measurements for the European territory.
Type & format	Geospatial (.nc)
Units	Percentage (%)
Update Frequency	Historical data archive 1988-2020 with the daily step.
Estimated Accuracy	RMSE: ca. 49%
Temporal coverage	Developed for 1988-2020
Spatial resolution	0.25°
Methodology	The product interprets LFMC as a weighted combination of vegetation optical depth estimated from passive microwave satellite observations and leaf area index within a logistic regression. The derived dataset is calibrated with the Globe-LFMC database and validated with the Globe-LFMC database as well as the MODIS LFMC based on the approach by Yebra et al. (2018) [41].
Contact	Matthias Forkel, TUD: Matthias.forkel@tu-dresden.de
Publication	[42] Forkel, M., Schmidt, L., Zotta, R. M., Dorigo, W., & Yebra, M. (2023). Estimating leaf moisture content at global scale from passive microwave satellite observations of vegetation optical depth. Hydrology and Earth System Sciences, 27(1), 39-68.
Overview	 *Example of the Live-fuel moisture content climate archive for selected days in 2003 (left) and the related relative uncertainty per pixel (right). Source: Forkel et al. (2023) [42]*

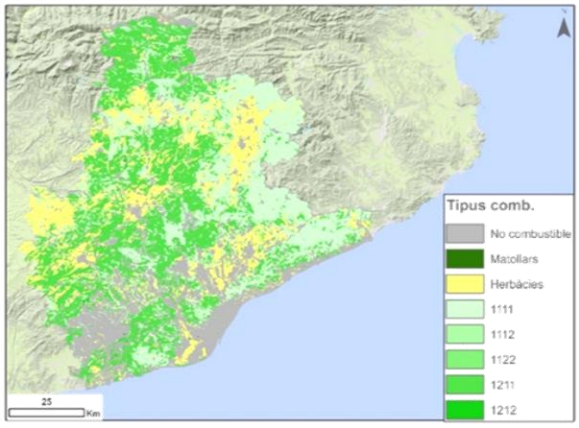
Copyright © FirEURisk Consortium. All rights reserved.

4.2.3. Fuel Sampling Protocol

Description	This product describes the main methodologies applied to sample the different vegetation types to be used as input in fire behaviour modelling. The protocol will refer to the main vegetation types (grass, shrub, forest understory) and will supply the most common methodology to measure fuel load, depth and cover.
Type & format	Document (pdf and .docx)
Methodology	Significant efforts have been devoted to quantifying and classifying fuel complexes [43] and developing fuel classification systems that attempt to cluster vegetation into unique categories with similar fuel properties (e.g., loadings) and similar potential fire behaviour, based on the requirement of specific modelling systems for fire behaviour and effects prediction [44], [45] The aim of this document is to describe several approaches to characterize fuel and to develop fuel classification for fire management, considering the most applied methodologies with particular attention to the effort needed for data sampling and classification. The document is structured in two Sections: • "Fuel properties and sampling methods" presents the main fuel components and the direct and indirect methods that have been proposed so far to estimate fuel load. Specifically, in section 2.3 two examples of direct methods are proposed: the destructive fuel sampling as applied within the framework of Proterina C project experience [46], [47], and the non-destructive fuel sampling based on [48], [49], [50]. In section 2.4 two example of indirect methods (photo series and photoload techniques) are illustrated. These procedures give managers both quantitative and visual records of various fuel complexes and allow the users to estimate the conditions of a field site by visually comparing the site to a series of photos. • "Fuel Classification", based on the work of Pellizzaro et al. (2015) [51], presents the most widespread and used fuel classification systems, analysing the approaches followed for their formulation and highlighting the main limitations and advantages, also taking into account the four main fuel description approaches illustrated by: association, opportunistic, classification, and abstraction [52].
Contact	Grazia Pellizzaro, CNR: grazia.pellizzaro@ibe.cnr.it Valentina Bacciu, CNR: valentina.bacciu@ibe.cnr.it
Overview	

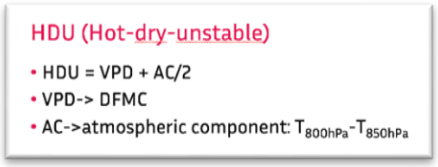
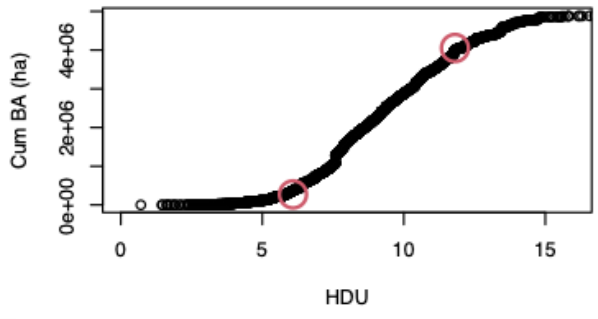
Copyright © FirEUrisk Consortium. All rights reserved.

4.2.4. Fuel type, fuel model, canopy metrics and landscape file

Description	This Product is a database contains the raster grids required to generate the landscape file at 100 m resolution for Pilot Sites (PS) (without Sweden), including following raster data themes are required: Elevation (m), Slope (degrees), Aspect (azimuth), new FirEUrisk Fuel Models and Canopy Cover (%), Canopy Height (m), Canopy Base Height (m) and Canopy bulk density (kg/m^3). The grids were downloaded from global products and resampled to 100 m resolution.
Type & format	Geospatial (.tif)
Units	Depends on data in dataset.
Update Frequency	No updates.
Estimated Accuracy	Depends on data for downscaling.
Temporal coverage	Depends on data in dataset
Spatial resolution	100 m
Methodology	In FlamMap five raster data themes are required in GeoTIFF file format. This file could be created from raster Lanscape file (.LCP) used in FARSITE and FlamMap 3. Lanscape raster file needs separate Projection file .PRJ and in multi-bend GeoTIFF file, the projection information is stored with the feature information in one file. At minimum, five raster data themes are required: Elevation, Slope, Aspect, Fuel model (FM) and Canopy Cover (CC). Other GIS layers are described as "optional": Canopy Height (CH), Canopy Base Height (CBH), Canopy bulk density (CBD). "Optional" means only that they are not required to run a surface fire simulation. However, these themes are required to calculate some aspects of fire behaviour (such as crown fire) that could be very important to the analysis. Detailed methodology for generating input files at 100 m resolution for all PS except Sweden is described in Technical Document: "D1.1. Report on methodological frameworks for each Danger modelling process".
Contact	Darko Stipanicev, FESB SPLIT: dstip@fesb.hr Maria Cristina Vega Garcia, UdL: cristina.vega@udl.cat
Overview	

Copyright © FirEURisk Consortium. All rights reserved.

4.2.5. Fire danger metric

Description	The Product is an algorithm used for fire danger assessment using a novel fire danger metric that couples surface and profile meteorology (different types of atmospheric stability), with dead and live fuel moisture status.
Type & format	Algorithm (R script) and Geospatial (.tif)
Units	Unitless
Update Frequency	Daily and weekly
Estimated Accuracy	>0.8
Temporal coverage	2001-2020
Spatial resolution	1 km (500m)
Methodology	Critical thresholds of fuel moisture and fire weather drivers associated with fire activity were defined and quantified for the Mediterranean ET. Estimated values of dead fuel moisture from a semi-mechanistic model and a remotely sensed vegetation index were used as proxy of live fuel moisture content. Fire weather was examined from a combination of surface variables including relative humidity, vapor pressure deficit, wind speed and, additionally, the Continuous Haines Index (C-Haines or CH) was used to indicate atmospheric instability. A detailed description of algorithm of calculation and data sources is available here: Resco et al. (2022) [53]and Rodrigues et al (2024) [54]. App web: https://hcfm.shinyapps.io/shinyfmd/ 
Contact	Victor Resco de Dios, UdL: v.rescodedios@gmail.com
Publication	[54] Rodrigues, M., de Dios, V. R., Sil, Â., Camprubí, A. C., & Fernandes, P. M. (2024). VPD-based models of dead fine fuel moisture provide best estimates in a global dataset. *Agricultural and Forest Meteorology*, *346*, 109868.
Overview	

Copyright © FirEURisk Consortium. All rights reserved.

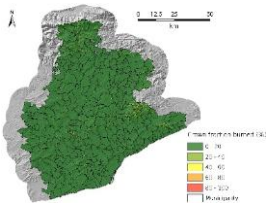
4.2.6. Wildfire spread and behaviour, FlamMap

Description	This product is a geodatabase that contains the fire spread and behaviour modelling outputs from FlamMap Basic Fire Behaviour to create '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. It was also used FlamMap Landscape Burn Probability to create 'dynamic' propagation potential maps having as output Landscape Burn Probability.
Type & format	Geospatial (.gdb)
Units	Fire intensity (kw/m), flame length (m), rate of spread (m/min), crown fire activity (class), crown fraction burned (percentage), and heat per unit area (kJ/m^2).
Temporal coverage	2021
Spatial resolution	100 m
Methodology	Steps in propagation potential calculation for each Pilot Site included: 1. Collecting essential weather data and fuel moisture data of past fires on PS territory in the last 20 years. 2. Preparation of input data in FlamMap form including estimate of other necessary fuel moisture input data that is calculated from initial data set. 3. Divide input weather and moisture data according to wind directions. 4. Filter the data and take only wind direction scenarios that are responsible for >10% historical fires. 5. Calculate annually burned area on average per wind direction scenarios. 6. Calculate 95-percentile and 50-percentile values for: live woody fuel moisture content, wind speed (gust) and 1h dead fuel moisture for selected wind direction scenarios. 7. Run FlamMap simulations for each combination of wind direction, wind speed and fuel moisture content. 8. Combine all the results. For the basic FlamMap run, burned area is used as a factor to combine the overall result. The procedure is to calculate the percentage of burned area (from overall burned area) that is happening for a certain combination of input data. It is important to know whether to assign the burned area to extreme or average scenario (the 50-percentile and the 95-percentile) for that wind direction scenario. 9. For the dynamic FlamMap run, all perimeters are put together. For dynamic mode, it is important to decide about duration of fires (we need to test different durations – 4h, 6h, 8h, 10h …), and results need to correlate to real historic data. To keep it simple, we will just take a look at larger fires. An additional step of calibration is necessary to decide on this. A detailed description of data sources, algorithm of calculation, and software use (FlamMap 6.2.7 from November 2022) is available at D1.1. "Report on methodological frameworks for each Danger modelling process", after page 165.
Contact	Maria Cristina Vega Garcia, UdL: cristina.vega@udl.cat

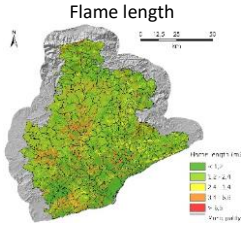
Copyright © FirEUrisk Consortium. All rights reserved.

Overview

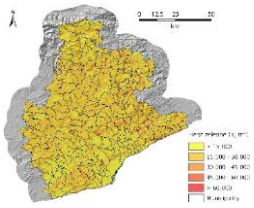
Crown fraction burned



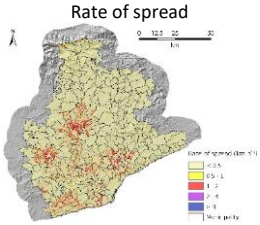
Flame length



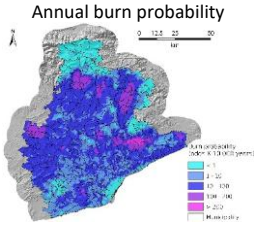
Heat release



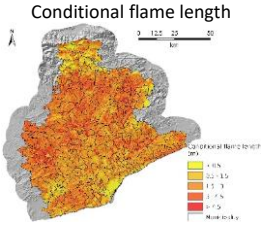
Rate of spread



Annual burn probability

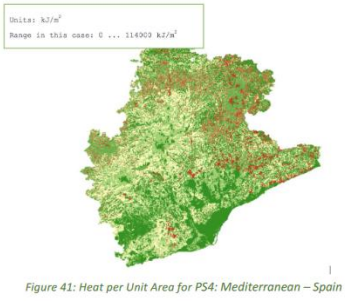
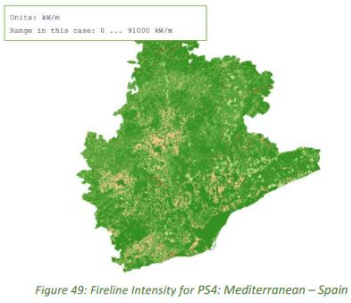
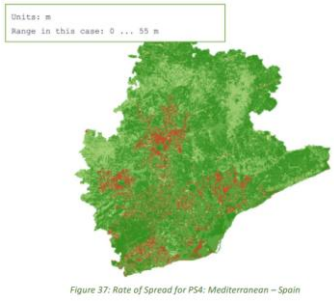


Conditional flame length



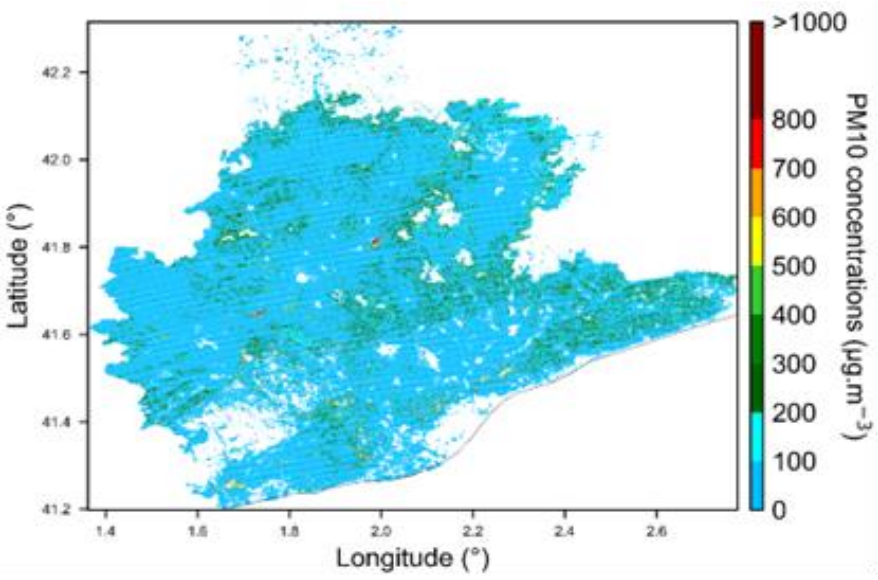
Copyright © FirEURisk Consortium. All rights reserved.

4.2.7. Propagation Potential Indicators for Pilot Sites, PP-PS

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/m^2), Flame Length (m), Fireline Intensity (kW/m), Crown Fraction Burned (%) and Crown Fire Activity.
Type & format	Geospatial (.tif)
Units	Not applicable
Update Frequency	If needed
Temporal coverage	Static layers
Spatial resolution	100m
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).
Contact	Darko Stipanicev, FESB SPLIT: dstip@fesb.hr Marin Bugarić, FESB SPLIT: marin.bugaric@fesb.hr
Overview	 *a) Heat per unit area*  *b) Fireline intensity*  *c) Rate of spread*

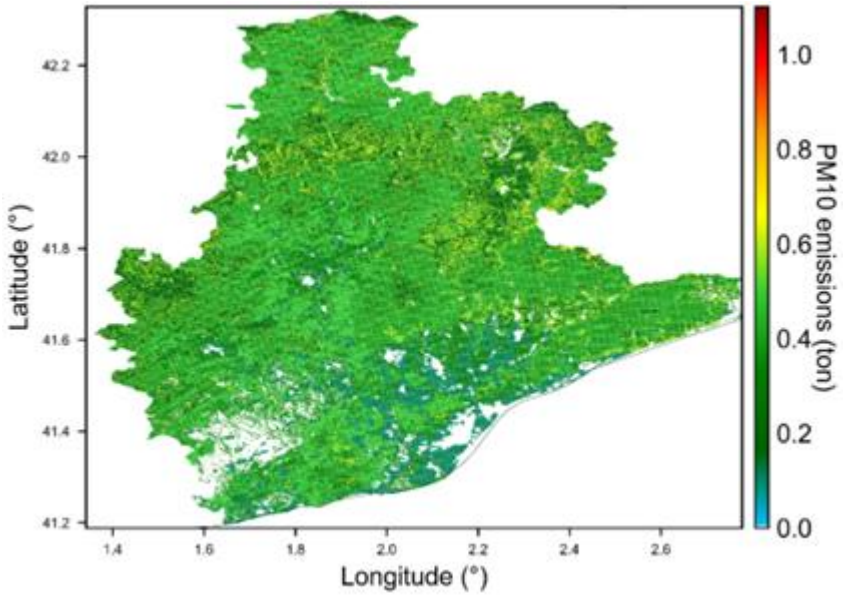
Copyright © FirEURisk Consortium. All rights reserved.

4.2.8. Smoke potential

Description	Smoke potential product provides the 2D air pollutant concentrations (e.g., PM10, PM2.5, NO_2 and CO) for the Pilot Site 3 (Mediterranean - Portugal) and Pilot Site 4 (Mediterranean - Spain). The final output is air pollutant concentrations ($\mu g/m^3$).
Type & format	Geospatial (.tif)
Units	$\mu g/m^3$
Update Frequency	Not applicable
Estimated Accuracy	Not applicable
Temporal coverage	Not applicable
Spatial resolution	≤ 100 m
Methodology	The methodology to estimate the smoke potential is based on the application of a Gaussian dispersion approach. The main input data required by this approach are meteorological parameters, fire rate of spread, heat per unit area, burnt area, fuel load, and fuel map.
Contact	Ana Isabel Couto Neto da Silva Miranda, UAVR: miranda@ua.pt
Overview	

Copyright © FirEURisk Consortium. All rights reserved.

4.2.9. Fire emission potential

Description	The product provides atmospheric emission potential (e.g., PM10, PM2.5, NO_2 and CO) for the PS3 (Mediterranean - Portugal) and PS4 (Mediterranean - Spain) pilot sites. The final output – atmospheric emission potential (ton) with a spatial horizontal resolution of ≤ 100 m.
Type & format	Geospatial (.tif)
Units	ton
Spatial resolution	≤ 100 m
Methodology	The methodology to estimate the atmospheric emission potential is based on fuel type, burnt area, fuel consumption, fire propagation, fire intensity, and emissions factors (by combustion phase: flaming and smouldering)
Contact	Ana Isabel Couto Neto da Silva Miranda, UAVR: miranda@ua.pt
Overview	 *Atmospheric emission potential in the PS4 (Mediterranean - Spain)*

Copyright © FirEURisk Consortium. All rights reserved.

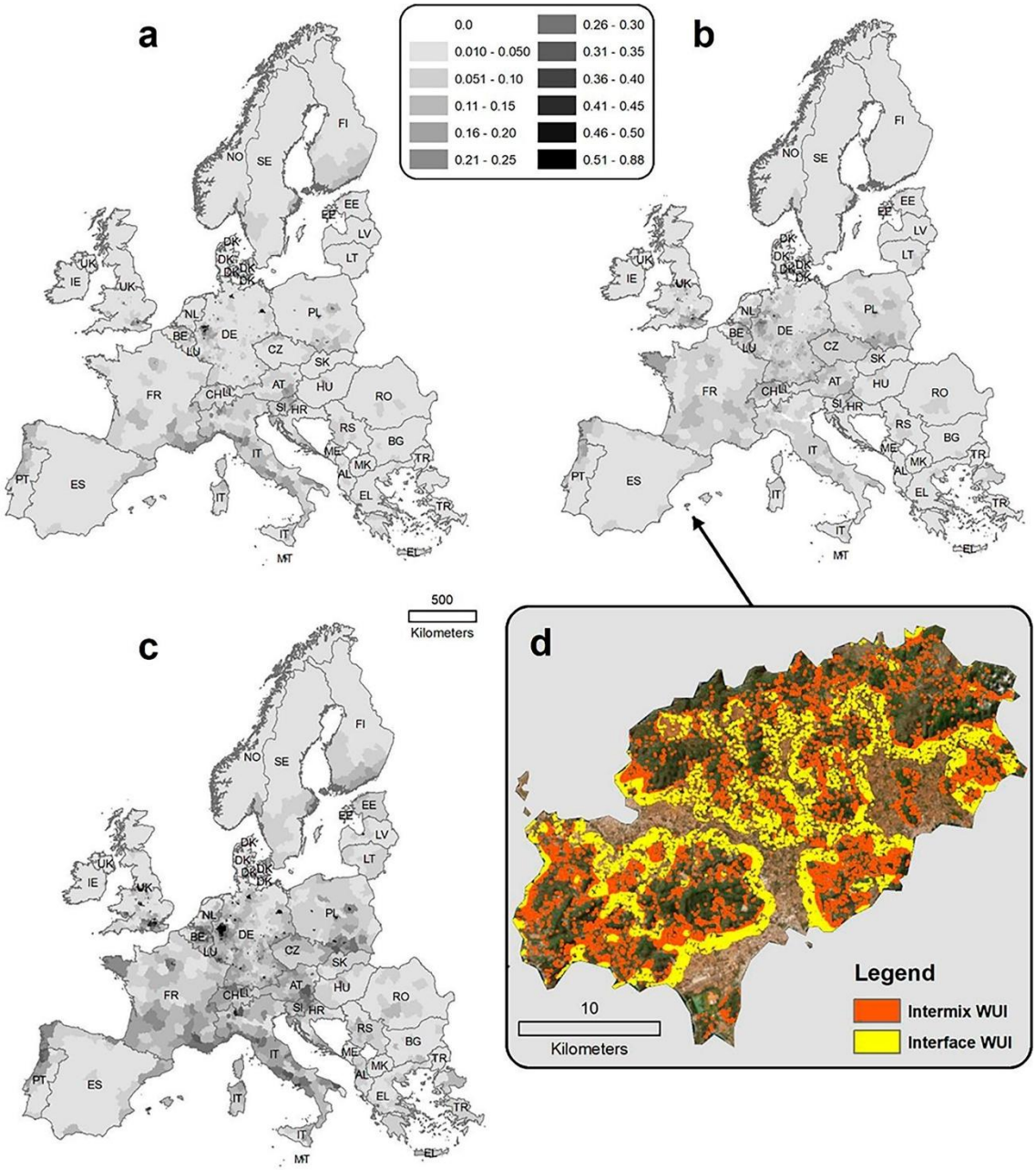
4.3. Exposure products

4.3.1. Wildland-Urban Interface map

Description	This product identifies the locations of Wildland-Urban Interfaces of two types, interface (where human settlements adjoin flammable vegetation) and intermix (where human settlements are interspersed with a matrix of flammable vegetation).
Type & format	Geospatial (.tif)
Units	Categorical: 0 - non WUI, 1 - intermix WUI, 2 - interface WUI
Update Frequency	Static layer
Estimated Accuracy	80-90%
Temporal coverage	2020
Spatial resolution	> 1 ha (10m)
Methodology	The mapping method builds upon the approach of Bar-Massada et al. (2012) [10]. 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.
Contact	Avi Bar Massada, HU: avi-b@sci.haifa.ac.il
Publication	[55] 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.

Copyright © FirEURisk Consortium. All rights reserved.

Overview



Proportion of WUI in NUTS-3 zones across Europe, 2020, for intermix WUI (a), interface WUI (b), and total WUI (c). Missing countries are those without NUTS-3 data. (d): high-resolution WUI map of the Island of Ibiza, overlaid on top of a true-colour satellite image (where dark colours depict wildland vegetation patches) Source: Bar-Massada et al. (2023) [55].

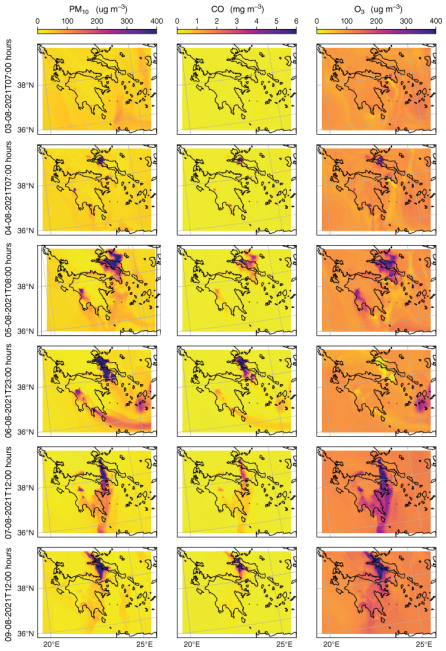
Copyright © FirEURisk Consortium. All rights reserved.

4.3.2. Forest fire emission forecast

Description	Forest fire emission forecast provides atmospheric emission forecasts (e.g. PM10, PM2.5, NO_2, CO) based on fire behaviour simulations, and if possible, on satellite data. The final output is the gridded emissions of relevant gases/aerosols (mass/area) of each wildfire with a spatial resolution lower than 1000 m. It is available for the North European pilot site but can be applied to estimate atmospheric emissions from other European wildfires.
Type & format	Geospatial (.tif)
Units	kg/m^2 or g/m^2
Update Frequency	Near-real time after wildfire ignition
Estimated Accuracy	Depends on fire progression forecast
Temporal coverage	Fire duration
Spatial resolution	≤1000 m
Methodology	The methodology to estimate the atmospheric emissions is based on emission factors (dependent on fuel types), burning efficiency, fuel loads, and burnt area. The latter is obtained by fire progression simulations run for each wildfire. Ignition locations have to be obtained from regional agencies or satellite detections. The accuracy assessment was done using either satellite estimates and detailed wildfire reports.
Contact	Ana Isabel Couto Neto da Silva Miranda, UAVR: miranda@ua.pt
Publication	[56] Osswald Tobias, Gama Carla, Fernandes Ana Patrícia, Lopes Diogo, Varela Vassiliki, Miranda Ana Isabel (2023) Effects of the wildfires in August 2021 on the air quality of Athens through a numerical simulation. International Journal of Wildland Fire 32, 1633-1645. https://doi.org/10.1071/WF22148

Copyright © FirEUrisk Consortium. All rights reserved.

Overview



Spatial distribution of the PM_{10}, CO and O_3 concentrations of simulated values at surface level from 3 to 9 August 2021. D03 results are overlaid on the D02 results. Source: Osswald et al (2023) [56].

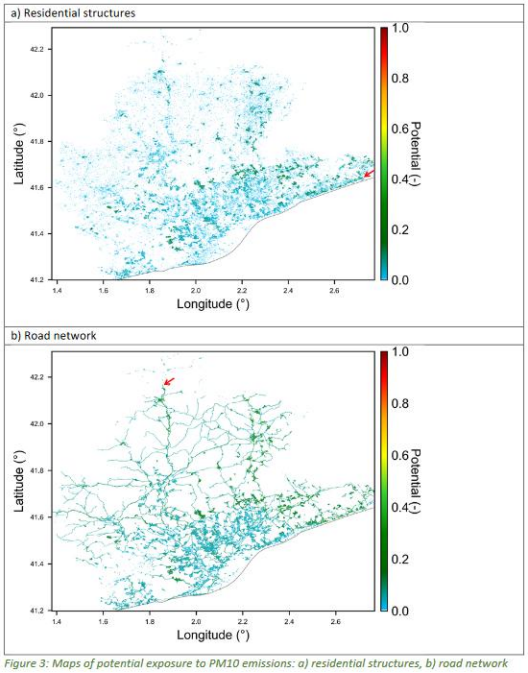
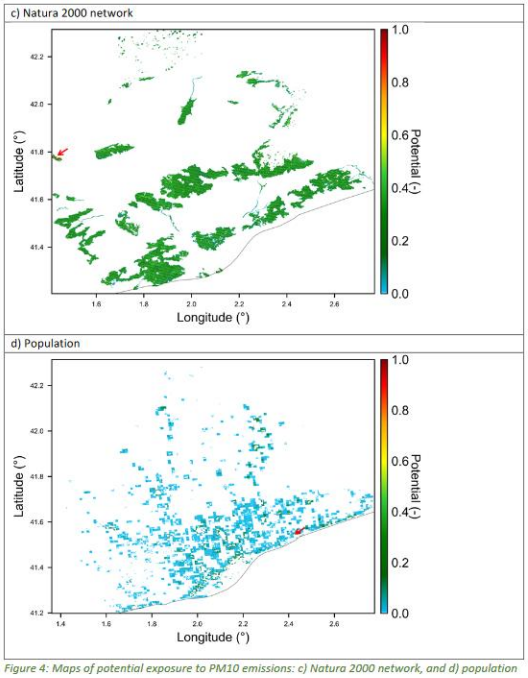
Copyright © FirEURisk Consortium. All rights reserved.

4.3.3. Smoke dispersion forecast

Description	Based on dispersion modelling, this product estimates 3D air pollution concentrations (e.g., PM10, PM2.5, NO2, CO) at local and regional scales. The final output is the gridded time-dependent ground-level concentrations of relevant gases/aerosols (µg/m^3) of each wildfire with a spatial resolution higher than 1000 m. It was applied to the Greek, Swedish, and Portuguese pilot sites.
Type & format	Geospatial (.tif)
Units	µg/m^3
Update Frequency	Near-real time after wildfire ignition
Estimated Accuracy	Uncertainty: 50% to 100%
Temporal coverage	Fire duration
Spatial resolution	≤1000 m
Methodology	The developed forecasting system – SmokeStorm – includes a chain of models, namely IMFIRE (for fire progression), DISPERFIRE (for local scale dispersion and emissions estimation), and CHIMERE (for regional scale chemical transport). These models were adapted to work together based on data flow analysis that specified required inputs and outputs. Static datasets (topography, fuel type) and dynamic inputs (meteorology, ignitions) feed into the system. Results were validated with local air quality measurements; for the Greek case application results were also compared to atmospheric optical depth.
Contact	Ana Isabel Couto Neto da Silva Miranda, UAVR: miranda@ua.pt

Copyright © FirEURisk Consortium. All rights reserved.

4.3.4. Maps of fire exposure metrics

Description	Fire exposure metrics product provides fire exposure potential of fire-related values (i.e., residential structures, road network, vegetation and animals' diversity, Natura 2000 network, and population) to the fire metrics (i.e., fireline intensity, rate of spread, atmospheric emission potential, and smoke potential) in the Pilot Site 3 (Mediterranean - Portugal) and Pilot Site 4 (Mediterranean - Spain).
Type & format	Geospatial (.tif)
Temporal coverage	2021
Spatial resolution	≤ 100 m
Methodology	The methodology is based on the juxtaposition of fire exposed related values (e.g., fireline intensity, rate of spread, fire emission potential, and smoke potential) with the spatial distribution of the fire metrics (fireline intensity, rate of spread, fire emission potential, and smoke potential).
Contact	Ana Isabel Couto Neto da Silva Miranda, UAVR: miranda@ua.pt
Overview	 Figure 3: Maps of potential exposure to PM10 emissions: a) residential structures, b) road network  Figure 4: Maps of potential exposure to PM10 emissions: c) Natura 2000 network, and d) population *Maps of potential exposure to PM 10 emissions in the PS4 (Mediterranean - Spain): a)residential structures, b) road network c)Natura 2000 network, and d) population*

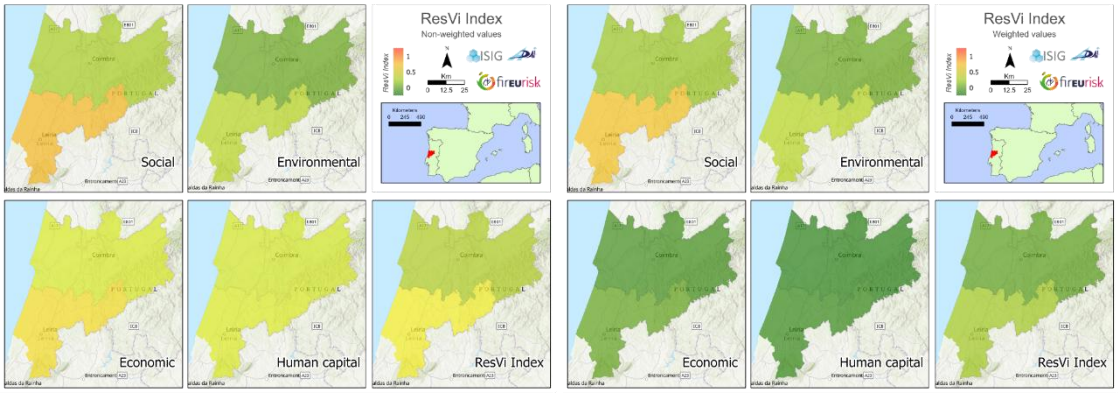
Copyright © FirEURisk Consortium. All rights reserved.

4.4. Vulnerability products

4.4.1. Relative Societal Vulnerability Index (RESVI) at community level

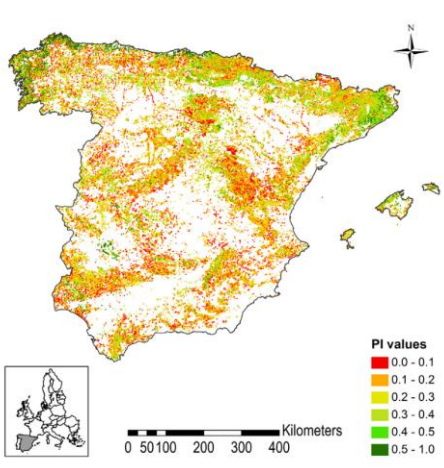
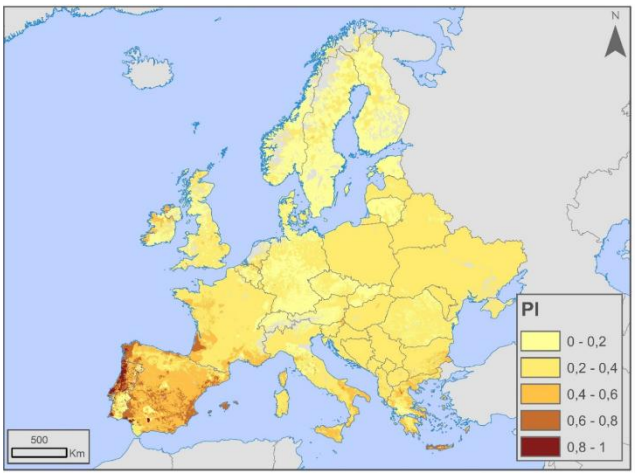
Description	This product is a tool designed to help local communities (namely local institutions and authorities, stakeholders, and practitioners) assess their societal vulnerability to hazards, such as wildfires. It enables the development of tailored resilience strategies at the community level by offering a structured, comparative approach to measuring vulnerability. The RESVI index comprises quantitative and qualitative data across five dimensions of societal vulnerability (social, economic, institutional, human capital and environmental) operates within a relative framework, comparing local communities to similar administrative units or higher tiers. RESVI may thus, among others, facilitate peer-to-peer learning and improved decision-making in wildfire risk management.
Type & format	Database (.xls)
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)
Spatial resolution	Territorial administrative units in the area of analysis (e.g., for the Barcelona Pilot Site analysis focus on Municipalities of the Province of Barcelona + the Province of Barcelona as a whole + the State)
Methodology	RESVI approach has been developed and implemented by ISIG for the analysis of coastal communities exposed to floods risk (ECOSTRESS DG ECHO), in a multi-hazard approach (RESILOC H2020), as well as for hydrogeological risks affecting mountain communities (RESBA and RISKGEST – Alcotra Interreg). 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. RESVI is composed by: • Dimensions: the underlying capitals interacting and constructing the community. • Indicators: variables that provide an operational representation of a characteristic of a community (i.e., indicators are grouped per relevant dimensions). • Proxies: indirect data sources contributing to the assessment of an indicator (i.e., proxies are grouped per relevant indicators). As a first step for the composition of RESVI, proxies are selected by end-users according both to their relevance for the community under focus, and the availability of data. This can be done through interviews and focus groups with relevant stakeholders on the field. Interviews and focus groups may also be exploited for the collection of qualitative data, once they are assessed as relevant. After the data is collected, the index is calculated. RESVI index takes into consideration two ways of combining proxies to calculate indicator, dimension, and overall vulnerability indexes. The first one is to calculate indicators proceeding through simple means, attributing the same weight (1) to all selected proxies. The second option takes into consideration the

Copyright © FirEUrisk Consortium. All rights reserved.

	relevance of the proxies attributed by the end-users, for instance weighting 0.5 the proxies with medium relevance and 1 the proxies with high relevance. Proxies are combined through simple or weighted means in order to calculate vulnerability dimensions indexes too. Eventually, the simple mean of vulnerability dimensions indexes constitutes the overall RESVI vulnerability index.
Contact	Riccardo Laterza, ISIG: laterza@isig.it
Overview	

Copyright © FirEUrisk Consortium. All rights reserved.

4.4.2. Persistence Index Map

Description	This geospatial product (algorithm and raster grids) provides a map of the Persistence Index; the Persistence Index reflects an ability of forest resistance and resilience to disturbances, based on the diversity, abundance, and redundancy of disturbance- and taxon-specific response traits. It can be applied to a broad spectrum of communities subjected to different types of stressors, making it a useful tool to guide ecosystem management decisions in a context of changing climate and uncertain disturbance regimes.
Type & format	Geospatial (.tif)
Units	Ratio between 0 (no persistence) and 1 (total persistence capacity), plot-based.
Update Frequency	Static
Estimated Accuracy	Depending on the input data on forest species distribution.
Temporal coverage	Static
Spatial resolution	Depending on the input data on forest species distribution
Methodology	In this product, we analysed species vulnerability to wildfires based on their recovery resilience. To achieve this, we examined the presence or absence of key functional traits across different tree species using data from the BROT species traits database. The selected traits—fire adaptation, seed banking ability, and resprouting capacity—are known to influence species recovery in burned forest ecosystems. To spatially contextualise our analysis, we applied the Persistence Index defined by Sánchez-Pinillos et al. (2016) [57] to the forest species map developed by the European Forest Institute (EFI). This approach allowed us to assess how the Persistence Index varies across different forest types in Europe, providing insights into species post-fire recovery potential.
Contact	Maria Cristina Vega Garcia, UdL: cristina.vega@udl.cat
Overview	 

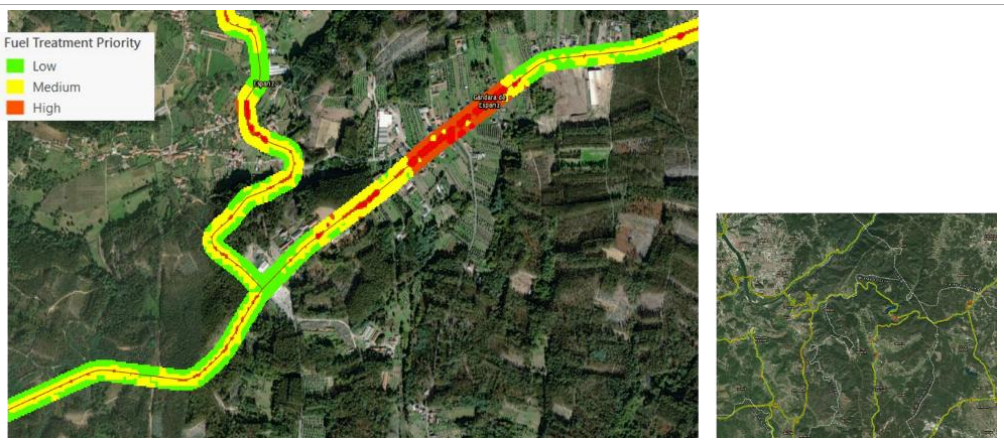
Copyright © FirEURisk Consortium. All rights reserved.

4.5. Risk mitigation and reduction products

4.5.1. Fuel Management Framework for Reducing Operation-based Ignitions, FuMaF_ROI

Description	The Product is a document that implement a fuel management framework, including procedures, rules-of-thumb, methods and spatial data layers specifications, for the reduction of operation-based ignitions.
Type & format	Geospatial (.tif) and Document (.doc)
Units	Not applicable
Update Frequency	Static (can be subsequently updated)
Temporal coverage	The output will be valid until significant changes occur in the input data (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).
Methodology	The product of Activity 2.1.2 is a Framework for the definition and prioritisation of areas for Fuel Reduction, aiming to the reduction of operations-based fire ignitions. The framework is based on the concept and methodology defined in EU-FP7 PREFER project ("Space-based information support for the Prevention and Recovery of Forest Fires Emergency in the Mediterranean Area" - G.A.312931), adapted for linear and point critical infrastructures (i.e. power grids, roads, railways) to depict and prioritise the areas that need to be treated. The methodology was based on the framework developed in PREFER project for fuel management and adapt to the specific needs of the FirEURisk activity for the reduction of operational ignitions. To this end: • additional spatial layers of risk elements were considered for improving the PREFER approach using advanced airborne sensing technology and methods to map linear infrastructure elements (powerlines, railways, road networks etc.) were identified: • specific (spatial) fuel management rules, methods, and relative physical thresholds to develop local fuel management maps using advanced airborne sensing technology (for mapping WHERE actions are necessary for reducing operations-based ignitions) have been defined The final product "Fuel Management Framework for the Reduction of Operational Ignitions" was adapted for linear and point critical infrastructures (i.e. power grids, roads, railways) to depict and prioritize the areas that need to be treated. The tools used included UAVs data & Satellite imagery, GIS spatial analysis tools and Fire Simulators. The following input thematic layers were analysed for the creation of the resulting Fuel Reduction map with three (3) priority classes (low, medium, high) of fuel treatment. • Power grid (lines) (High-Medium-Low voltage) • Power substations/pylons/transformers (WUI areas) (points) • Railway network (lines) • Road network (lines, (National, Provincial, Municipal) • Other installations related to road and railway networks (points) • Topography (i.e. elevation, slope, aspect) • Fuel Type map based on FirEURisk fuel types • Climatic characteristics/ Zone (Dry, Mild, Wet)

Copyright © FirEURisk Consortium. All rights reserved.

	• 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) The data analysis was performed in two levels, A) PS level analysis B) DA level analysis and included 3 steps: Step A: Regional/PS Level Analysis 1. Layer Overlay: This step involves creating a composite map by overlaying two key layers - the infrastructure networks (power grid, roads, railways) and the vegetation layers (fuel maps or satellite imagery). 2. Identification of Risk Areas: The overlaid map is then analysed to identify regions where vegetation encroaches upon a predefined buffer zone around the infrastructure. These areas are marked as lines or polygons, indicating potential risk zones. Step B: Local/DA Level Analysis 1. Drone Surveillance: In selected areas, drones are deployed to conduct a detailed survey along the network lines. 2. High-Resolution Mapping: The drone flights provide high-resolution data, enabling precise identification of specific locations where vegetation is too close to the operational network, necessitating fuel treatment. Step C: Prioritisation and Treatment Planning 1. Data Elaboration: The high-resolution data from Step B is thoroughly analysed to understand the nuances of the challenge. 2. Intervention Prioritisation: Based on factors such as the type and volume of vegetation, topography, accessibility, and proximity to the network, interventions are prioritized. 3. Treatment Definition: Finally, the type of vegetation management or fuel treatment required is defined for each prioritised area. This could involve methods like controlled burns, mechanical clearing, or chemical treatments, tailored to the specific needs of the location.
Contact	Vassiliki Varela, AUTH: vassiliki.var18@gmail.com
Overview	 *Map of fuel reduction priority around roads in Pilot Site 3 (Portugal)*

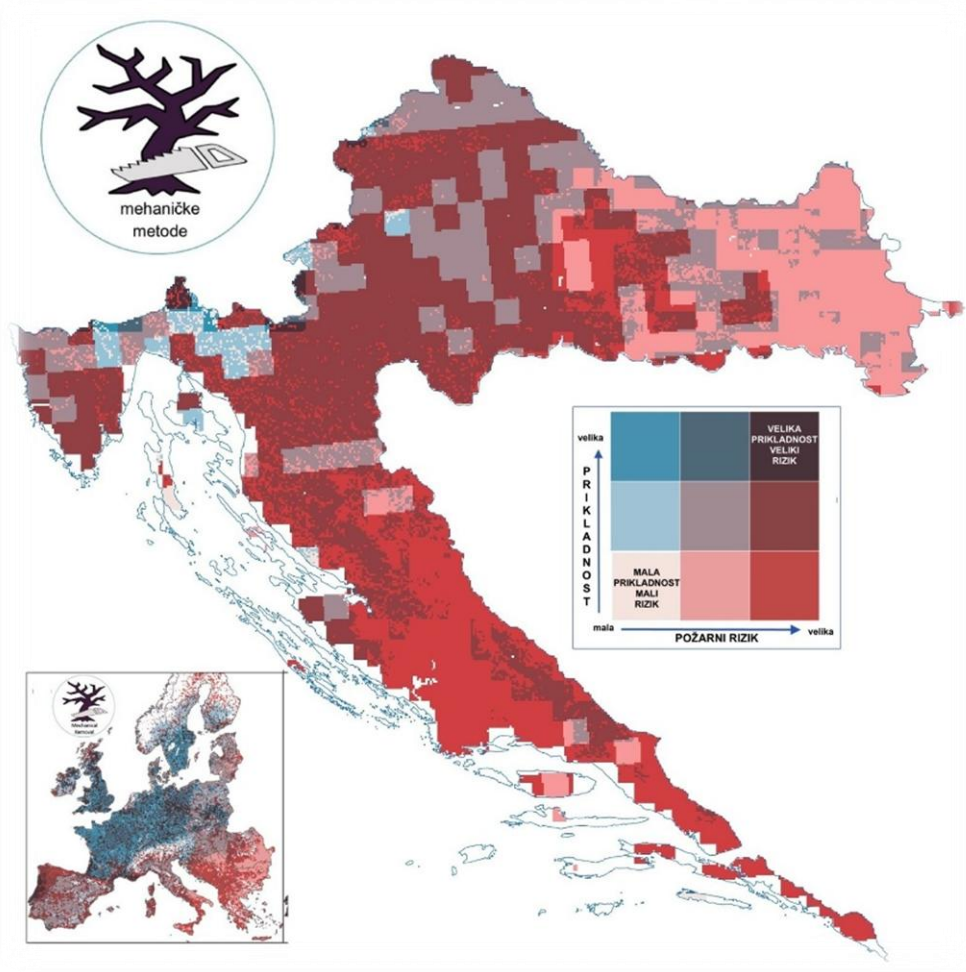
Copyright © FirEUrisk Consortium. All rights reserved.



Map of fuel reduction priority around roads in Pilot Site 5 (Greece)

Copyright © FirEURisk Consortium. All rights reserved.

4.5.2. Land Management Strategies for Adriatic area

Description	The Product is a document created based on the analysis of possible Land Management Strategies (LMS) strategies used in various EU countries. LMS are activities which change vegetation or landscape structure with a (partial) aim to reduce wildfire risk. In the Product was proposed the most suitable strategies for Adriatic area with detail description how to use them
Type & format	Document (.pdf)
Methodology	To participate in analysis of the interaction between weather, fuels and topography associated to extreme fire behaviour, particularly eruptive fires. We will analyse which LMS strategies from the inventory are most suitable for use in our DA in Split-Dalmatia County
Contact	Darko Stipanicev, FESB SPLIT: dstip@fesb.hr
Overview	

Copyright © FirEURisk Consortium. All rights reserved.

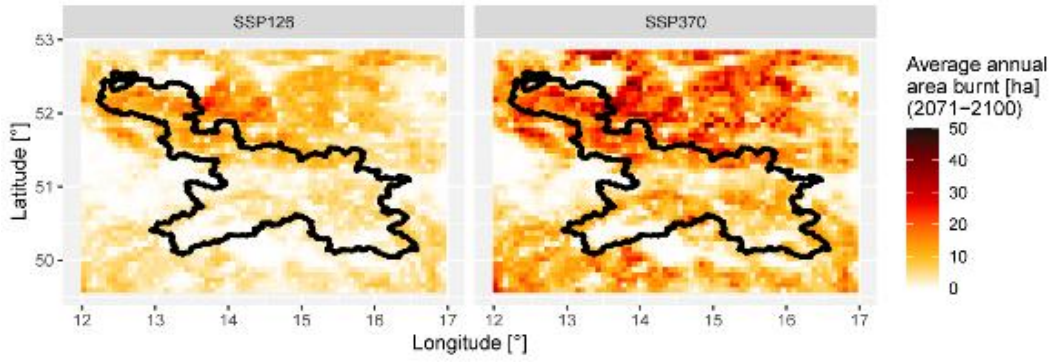
4.6. Risk adaptation products

4.6.1. Future climate information

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.
Type & format	Geospatial product (.shp, .tif), document with projection graphs (.pdf)
Units	Expected changes (ºC, mm, number of days or events…)
Update Frequency	Provided once
Estimated Accuracy	Variable uncertainty.
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
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).
Contact	David Caballero Valero, METEOGRID SL: david@meteogrid.com

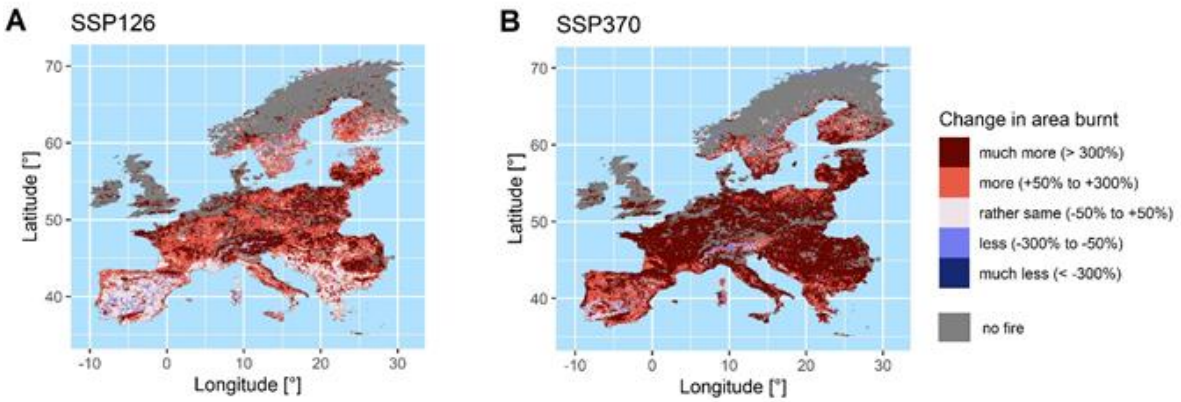
Copyright © FirEURisk Consortium. All rights reserved.

4.6.2. Future fire regime database

Description	This product contains changes in future fire regimes (fire ignitions, burned area, fire intensity, biomass burned) compiled from simulated spatio-temporal fire variables of fire-enabled DGVMs.
Type & format	Geospatial (.nc)
Units	Ha, kgC/m², fraction of grid cell (depending on variable)
Temporal coverage	2020-2100
Spatial resolution	> 1 km (9 km)
Methodology	The product contains information on simulated future fire regimes using the LPJmLv5.6-SPITFIRE and LPJmLv5.6-SPITFIRE-BASE vegetation-fire models. SPITFIRE is a process-based fire model, developed at PIK, the performance of which was improved and documented in Deliverable D3.3. The Burnt Area Simulator for Europe (BASE) is an empirical burned area model, developed by SGN (with contributions from TUD, LSCE/UVSQ and IRD) that is based on remotely sensed information using generalised linear model (GLM) techniques, provided by several data sources, originated—among others— from FirEUrisk. This product contains a set of future changes in vegetation and fire variables under future climate and land-use change at the European Territory (ET) at 9 km covering the period 2003-2100. The fire-enabled Dynamic Global Vegetation Model (DGVM) was forced with outputs from 5 climate models from the SSP126 and SSP370 climate scenarios (as described in D3.1 as well as the land-use projections corresponding to those climate scenarios (as described in D3.2). The variables provided in this dataset are at monthly (fire) and annual (vegetation) temporal resolution. Simulated changes in the spatiotemporal patterns of fire and vegetation are the result of changes in climate and land use and the resulting fire-vegetation feedbacks. Detailed description of algorithm of calculation and data sources available here: Deliverable D3.4 "Simulated fire and vegetation dynamics at three spatial scales".
Contact	Kirsten Thonicke, PIK: Kirsten.Thonicke@pik-potsdam.de Maik Billing, PIK: Maik.Billing@pik-potsdam.de
Publication	**Dataset:** [58] Billing, Maik; Forrest, Matthew; von Bloh, Werner; Bowring, Simon; Hetzer, Jessica; Oberhagemann, Luke; Thonicke, Kirsten (2023): Projections of future fire and vegetation variables on European scale (Dataset]. GFZ Data Services. https://doi.org/10.5880/pik.2023.005
Overview	

Copyright © FirEUrisk Consortium. All rights reserved.

i) Simulated future burned area in the central European demonstration area using LPJmL-SPITFIRE. The simulated changes result from climate change (shown are averages over simulations using 5 different climate models for each scenario) and the corresponding changes in land cover. Vegetation composition and burned area result from changes in climate and changes in potential burned area due to land-cover change.



ii) Relative changes in simulated burnt area between years 2000 – 2030 and 2070 – 2100 for SSP126 (panel A) and SSP370 (panel B) using LPJmL-SPITFIRE

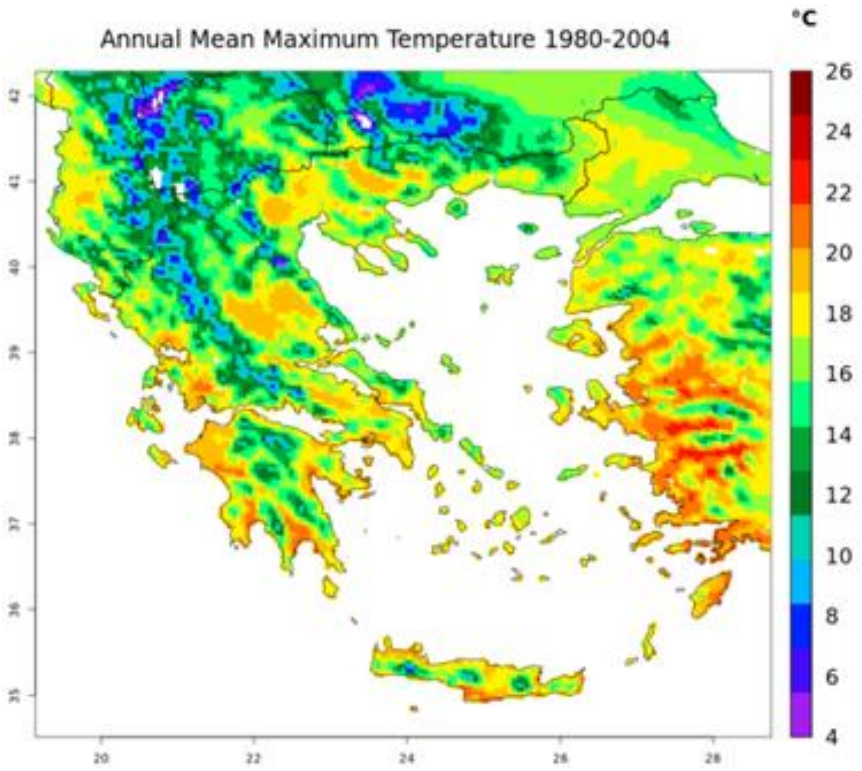
Copyright © FirEUrisk Consortium. All rights reserved.

4.6.3. High resolution future climate information for Greece

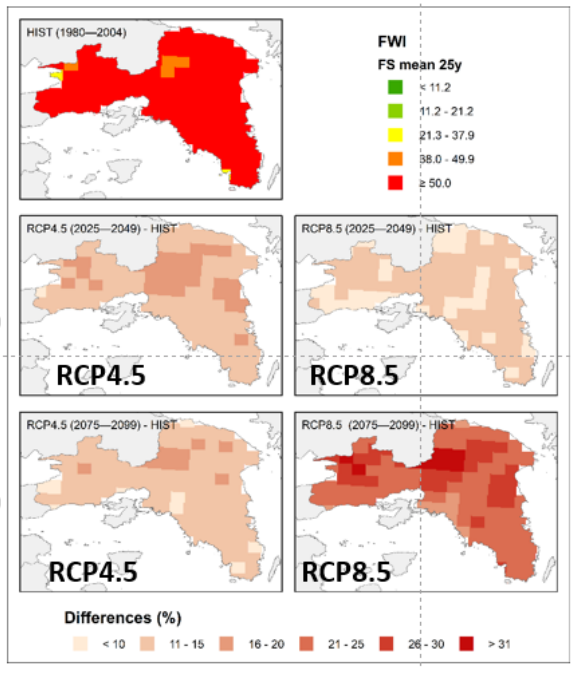
Description	Product is a high-resolution future climate (maximum and minimum temperature, precipitation, relative humidity, wind speed) and fire weather components datasets in daily temporal resolution for Attica region at 5 km resolution, using dynamical downscaling methodology.
Type & format	Geospatial (.csv)
Units	Depends on climate variable and Fire Weather Index (FWI) classes
Temporal coverage	Historical (1980–2004), mid-century (2025–2049), and end of century (2075–2099) periods.
Spatial resolution	5 km
Methodology	The dynamical downscaling technique was applied through the non-hydrostatic (WRF-ARW) model in version 3.6.1. The WRF model dynamically downscaled EC-EARTH global climate simulations to produce these high-resolution datasets of 5 km horizontal resolution for the area of Greece. These weather variables were generated for two future time periods and under two emission scenarios (RCP4.5 and RCP8.5). Historical simulations, for the period 1980–2004, were included to provide a reference period for the projection. Validation studies of the climate datasets with the available meteorological data from the Hellenic National Meteorological Service (HNMS) by (Politi et al., 2022, 2021) included in detail the overall description of the procedure, model setup and results of the model performance with statistical indices. These studies demonstrated the model's ability to accurately reproduce historical spatial and temporal climate patterns of surface variables, establishing its credibility for climate projections. The overall methodology can be found in the aforementioned references and is also described in Deliverable D3.1. The produced climate datasets were also used for the calculation of the Canadian Fire Weather components. FWI components were calculated over the land grid cells in the area for were each grid point and for each time period. These products were used to determine spatially the climate signal of fire weather conditions and for fire regime future simulations for PS5 (Attica Region).
Contact	Nadia Politi, NCSRD: nadiapol@ipta.demokritos.gr
Publication	The results can be found in the StoryMap, in the section "Fire Weather Danger Assessment under RCP4.5 and RCP8.5 climate Change Scenarios" in https://fireurisk.eu/greece/

Copyright © FirEUrisk Consortium. All rights reserved.

Overview



Estimation of mean FWI change for the Fire season in the near and far future for RCP4.5 and RCP8.5



Copyright © FirEURisk Consortium. All rights reserved.

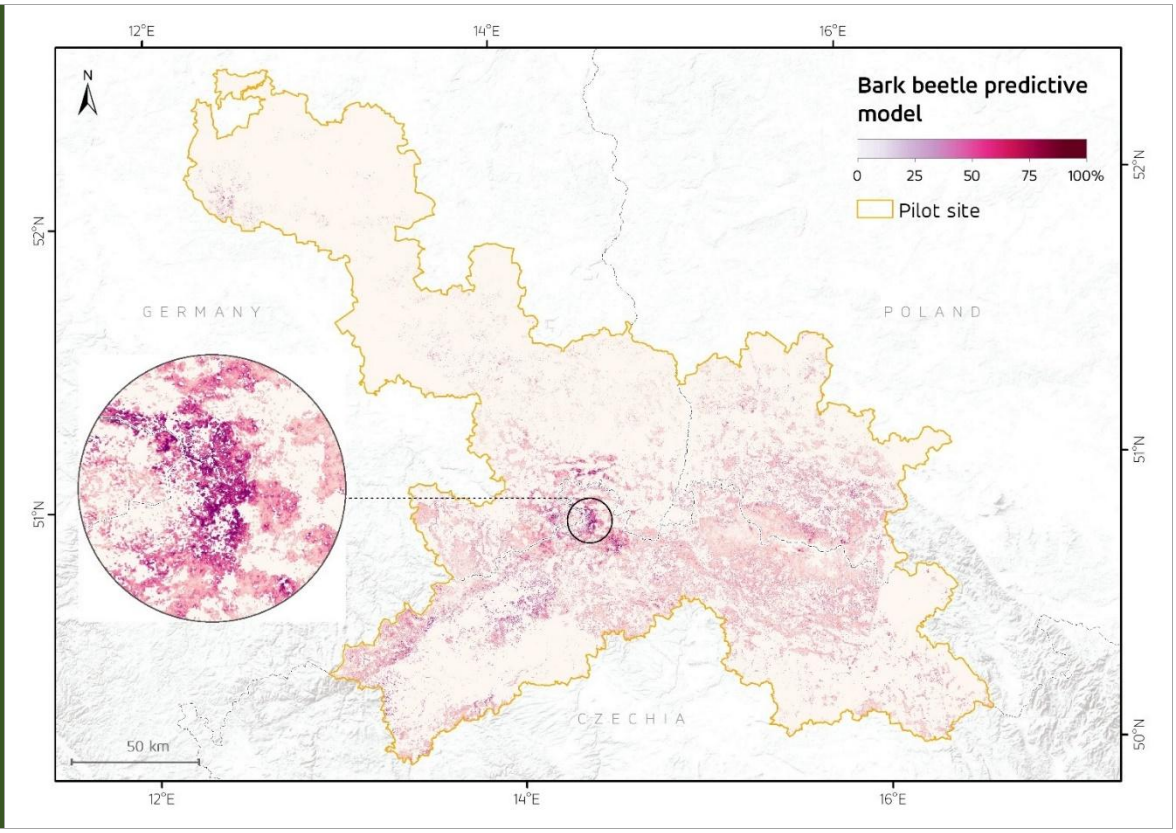
4.7. Instrumental products

4.7.1. Forest condition biotic damages

Description	This product predicts the probability of a bark beetle (*Ips typographus*) attack assessing a set of risk factors that predispose forests to pest infestations and wildfires for Central-Eastern Europe Pilot Site. This technological solution aims to identify areas predisposed to bark beetle infestation using EO-based and machine learning techniques. Geospatial results will be provided in raster format (.tif) to help managers optimise their resources and mitigate the negative effects of plagues and wildfires. The output is a map showing predicted bark beetle attack probability from 0 to 100.
Type & format	Geospatial (.tif)
Units	Percent (%)
Update Frequency	Seasonal
Estimated Accuracy	At the demonstration area, the model yielded the following metrics over a test set of 20% on the data: RMSE = 0.03, MAE = 0.11. The product was validated using reference data from the Saxon Switzerland National Park, obtaining the following metrics: Accuracy = 92.3%, F1-score = 81.6%, commission error = 31.2%, omission error = 46.4%, relative bias = 22.2%.
Temporal coverage	2017 - 2024
Spatial resolution	50 and 100 m
Methodology	GMV will estimate past biotic damages caused by bark beetle outbreaks [59] in Central-Eastern Europe (Germany, Poland, Czech Republic) and evaluated the influence of environmental traits that predispose forests to a bark beetle infestation [60], [61]. Preprocessing risk factors involved cleaning data to fill or discard missing records (e.g., clouds), eliminate inconsistencies, and standardise datasets. Different indicators were calculated and selected through a feature engineering process to generate the input variables. These variables were ranked using Gini impurity decrease to understand their effect on bark beetle. Different classical and Artificial Intelligence architectures were tested to produce a predictive model of bark beetle attack. Hyperparameter tuning was carried out using iterative random/grid search and cross-validation. The best model was selected to produce a raster showing the predicted bark beetle damage. The integration of the biotic damages will be analysed within the framework of the A4.2.3. Cascading effects and other fire and non-fire hazards in Central Europe.
Contact	Marta Gómez-Giménez, GMV: mggimenez@gmv.com
Publication	[62] Fernández-Carrillo, Á., Franco-Nieto, A., Yagüe-Ballester, M. J., & Gómez-Giménez, M. (2024). Predictive Model for Bark Beetle Outbreaks in European Forests. Forests, 15(7), 1114. https://doi.org/10.3390/f15071114 **Dataset:** [63] Fernandez-Carrillo, A., Franco-Nieto, A., Yagüe Ballester, M. J., & Gómez-Giménez, M. (2024). Bark beetle predictive model results (FirEUrisk) (Dataset]. Zenodo. https://doi.org/10.5281/zenodo.12533018

Copyright © FirEUrisk Consortium. All rights reserved.

Overview



Copyright © FirEURisk Consortium. All rights reserved.

4.7.2. Program of prescribed burnings

Description	The product proposes the adoption of prescribed burning as an effective tool for preventing fire ignitions in agropastoral and agroforestry contexts. Several phases of activity development are outlined: an initial phase of introductory analysis on the state of the art of prescribed burning and the existing regulations, aimed at identifying the regulatory frameworks that facilitate its adoption. Subsequently, the design and implementation of experimental training courses are proposed, with particular attention to the management and planning of the sessions. These include the assessment of landscape and environmental conditions necessary to identify the optimal time windows for interventions. Finally, the document provides an evaluation of the activities carried out, including an analysis of the organizational methods and operational effects of the training sessions on various stakeholders, such as farmers, forestry professionals, and agencies involved in fire management
Type & format	Document (.pdf)
Methodology	The methodology comprised the following key phases: • Initial Context Analysis and Stakeholder Engagement. The process began with consultations with local stakeholders (e.g., farmers, municipal authorities, and forestry agencies). This phase allowed to identify community needs, environmental constraints, and areas for prescribed burning. Socio-economic factors and fire regime analyses need to be integrated into the planning process. • Planning and Design of Prescribed Burning. Detailed prescribed burning plans are developed including environmental, orographic, and weather conditions to define implementation windows. Key parameters, such as fuel load, moisture content, slope, and vegetation type, need to be assessed to ensure safety and effectiveness. Anchor lines and firebreaks need to be planned to minimize risks. • Training Sessions. Training programs consist of theoretical and practical components: • Theoretical Training: Covering regulations, risk assessments, safety protocols, and fire management techniques. Farmers can be trained in planning burns, creating firebreaks, and adhering to safety guidelines. • Field Training: Practical sessions involve controlled burning exercises under supervised conditions. Participants learn ignition techniques, fire behaviour management, and the use of tools like drip torches and blowers. • Execution of Prescribed Burns. Field operations need to be conducted in phases, starting with test ignitions to ensure safety and feasibility. Controlled burns can be implemented using different patterns of ignitions and monitored for flame intensity and spread to achieve fuel reduction objectives. • Evaluation and Monitoring. Data on fire behaviour, fuel load, and environmental impacts should be collected during and after the burns. This information can used to refine practices, ensure compliance with environmental regulations, and assess the effectiveness of interventions in reducing wildfire risk. • Community Involvement and Communication. Public awareness campaigns need to be conducted to inform local communities about the purpose and benefits of prescribed burning. Farmers can gain autonomy to conduct burns safely under regulated conditions. **Key Achievements:** The methodology fosters interdisciplinary collaboration, improves wildfire prevention strategies, and promotes sustainable land management. It also enhances the capacity of local stakeholders to manage fire risk while maintaining biodiversity and agro-pastoral productivity. The training programs in Sardinia and the French Alps can serve as replicable models for other regions facing similar challenges.

Copyright © FirEUrisk Consortium. All rights reserved.

Parameter	Minimum	Optimal	Maximum
Air temperature (°C)	12	16-25	30
Air relative humidity (%)	12	20-35	55
Wind speed (km/h)	2	3-8	12
Fuel moisture (%)	7	10-12	15
Days from the last precipitation > 10 mm	1	2-3	5
Slope (°)	0	10-20	100
Crown base height (m)	2	3	
Spot fire		absent	limited
Rate of spread (m/min)	1	2-4	8
Fireline Intensity (km/m)	150	200-250	400
Flame length (m)	0.3	0.6-0.7	1.20
Fuel load reduction objective (%)	85	95	100

Example of the main parameters for the evaluation of the prescribed burning implementation window

Proved accuracy at Demonstration Area:

As far as Sardinia is concerned, several field activities took place from 2020 to 2023, under the weather conditions established in the prescribed burning plan, which defined an implementation window and specific prescriptions regulating the execution of interventions.

- Municipality of Suni: during the 2020-2023 period, up to 30 hectares per day were treated, with an intervention implementation window of about 15-20 days. In spring 2023, a classroom training session targeting farmers (about 10 people) was held focusing on addressing safety issues in cases of controlled fire interventions.
- Municipality of Alghero (location of Surigheddu): in 2022 and 2023, specific training for about 70 operators per year; total treated area of about 35 ha per year.
- Municipality of Isili (central Sardinia): in 2021 and 2022, prescribed burnings carried out in agro-silvopastoral area, with variable canopy cover, but in some cases with closed vegetation trees.
- Municipality of Nuoro and Bonorva (central Sardinia): prescribed burnings to protect WUI areas.

In the French Alps, according to the methodology developed above, training sessions were realised for pastoral farmers (breeders) in 2022 and 2023, in Digne area:

- February 2022, 2 days training including general presentation and initiation prescribed burns
- February and March 2023, 3 days training including 3 prescribed burns.

Interesting results were observed, e.g., firefighting training, reducing emissions from wildfires, lowering fire risk through the reduction of fuel load and continuity, farmers involvement, demonstrating the effectiveness and accuracy of the interventions in the "Demonstration Areas". Following the initiative, the practitioners trained have implemented more prescribed burns in 2024 and 2025, both in the French Alps and in Sardinia. Other trainings are also planned for the next years.

Contact

Michele Salis, CNR: michele.salis@ibe.cnr.it

Overview





Copyright © FirEUrisk Consortium. All rights reserved.

4.7.1. Handbook with guidelines to face extreme fires, and fires in Wildland-Urban Interface areas

Description	Short handbook about extreme and dangerous wildfire behaviours (crown fires, spot fires, eruptive fire, fire whirls, merging fires). This task is translation in Croatian of D2.6.
Type & format	Document (.pdf)
Methodology	To participate in preparation of handbook for firefighters and managers on extreme fire behaviour and WUI challenges, as well as its customisation those handbooks for Croatian users.
Contact	Darko Stipanicev, FESB SPLIT: dstip@fesb.hr
Publication	D2.6 Handbook with guidelines for fire fighters to face to extreme fires, fires in Wildland-Urban Interface and fires in high latitudes/ altitudes.
Overview	 **FIREURISK – RAZVOJ HOLISTIČKE STRATEGIJE ZA UPRAVLJANJE POŽARNIM RIZICIMA** **Broj ugovora: 101003890** **Identifikator poziva:** H2020-LC-CLA-2018-2019-2020 **Tema:** LC-CLA-15-2020 Smanjenje rizika od požara raslinja: korak prema pristupu integriranog upravljanja požarima raslinja u EU **Instrument:** RIA ***Priručnik sa smjernicama za vatrogasce za suočavanje s ekstremnim požarima, požarima u graničnom području naseljenih i divljih (prirodnih) područja i požarima na velikim geografskim širinama i visinama*** **Identifikator dokumenta:** **Diseminacija rezultata projekta FirEUrisk za području Republike Hrvatske.** **Rok za izradu dokumenta:** 31.03.2025. **Datum izrade dokumenta:** 01.11.2024. **Verzija:** 1.0 **Glavni dokument:** **D2.6 Handbook with guidelines for fire fighters to face to extreme fires, fires in WUI and fires in high latitudes/ altitudes** **Autor glavnog dokumenta i glavni partner ovih istraživanja:** Sébastien Lahaye, Domingos Xavier Viegas, Luis Mario Ribeiro, Miguel Almeida, Tiago Rodrigues, Antonio Jorge Ferreira, Ana Isabel Miranda, Diogo Lopes, Tobias Osswald, Johan Sjöström, Rick McRae, Kiki Yunianti, Fanny Verhilac **Prijevod, obrada slika i prilagodba za Hrvatsku:** Darko Stipaničev, Maja Braović, Damir Krstinić, Ljiljana Šerić, Marin Bugarić, Fakultet elektrotehnike, strojarstva i brodogradnje Sveučilišta u Splitu, Split, Hrvatska **Radni paket:** **WP2 - Smanjenje rizika od požara radi poboljšanja zaštite** **Zadatak:** **Zadatak 2.3. Smanjenje rizik od ekstremnih požara** **Razina širenja:** ☒ PU: Javno ☐ CO: Povjerljivo, samo za članove Konzorcija (uključujući Službe Komisije)

Copyright © FirEUrisk Consortium. All rights reserved.

5. Portfolio of Local Products for an Integrated Wildfire Risk Management Strategy

5.1. Summary of the portfolio

The **FirEUrisk Local Products Portfolio** provides **nineteen products**, tested and demonstrated in the pilot sites and demonstration areas across the Europe. Figure 14 below traces each local product to the specific wildfire integration factor that contributes to resolve.

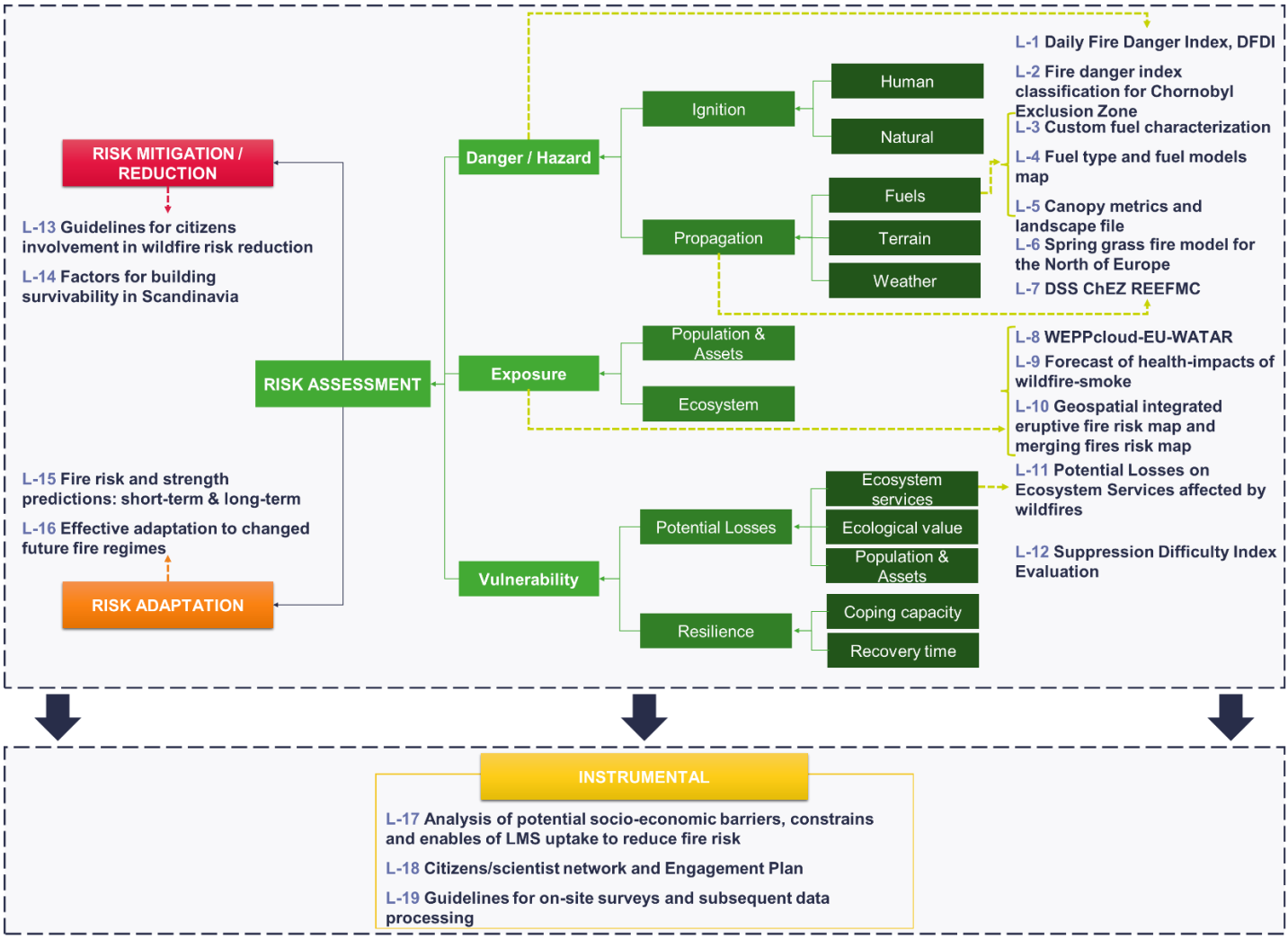


Figure 14. FirEUrisk Local Products schema.

Copyright © FirEUrisk Consortium. All rights reserved.

Table 10. FirEUrisk Local Products Portfolio

Id	FirEUrisk Local Products	Integration of fire risk components	Producer	TRL
L-1	Daily Fire Danger Index	Danger	SIA	TRL 6
L-2	Fire danger index classification for Chornobyl Exclusion Zone	Danger	REEFMC	TRL 7
L-3	Custom fuel characterization	Danger	UdL	TRL 3
L-4	Fuel type and fuel models map	Danger	INCDS	TRL 2
L-5	Canopy metrics and terrain files	Danger	ARBONAUT	TRL 4
L-6	Spring grass fire model for the North	Danger	RISE	TRL 5
L-7	DSS ChEZ REEFMC	Danger	REEFMC	TRL 7
L-8	WEPPcloud-EU-WATAR	Exposure	SU	TRL 7
L-9	Forecast of health impacts of wildfire smoke	Exposure	UAVR	TRL 3
L-10	Geospatial integrated eruptive fire risk map and merging fires risk map	Exposure	FESB SPLIT	TRL 3
L-11	Potential Losses on Ecosystem Services affected by wildfires	Vulnerability	UCO	TRL 5
L-12	Suppression Difficulty Index Evaluation	Vulnerability	UCO	TRL 5
L-13	Guidelines for citizens involvement in wildfire risk reduction	Mitigation	FESB SPLIT	TRL 3
L-14	Factors for building survivability in Scandinavia	Mitigation	RISE	TRL 5
L-15	Fire risk and strength predictions: short-term & long-term	Adaptation	FMI	TRL 5
L-16	Effective adaptation to changed future fire regimes	Adaptation	PIK	TRL 5
L-17	Analysis of potential socio-economic barriers, constrains and enables of Land Management Strategies uptake to reduce fire risk	Instrumental	HUTTON	TRL 3
L-18	Citizens scientist network and Engagement Plan	Instrumental	ISIG	TRL 5
L-19	Guidelines for on-site surveys and subsequent data processing	Instrumental	ADAI	TRL 3

Copyright © FirEUrisk Consortium. All rights reserved.

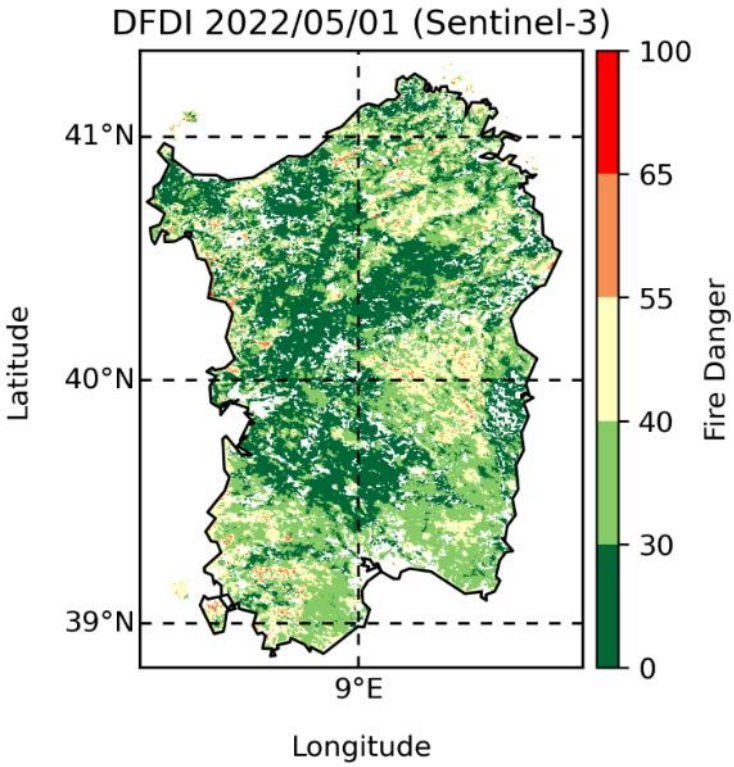
5.2. Danger or hazard product

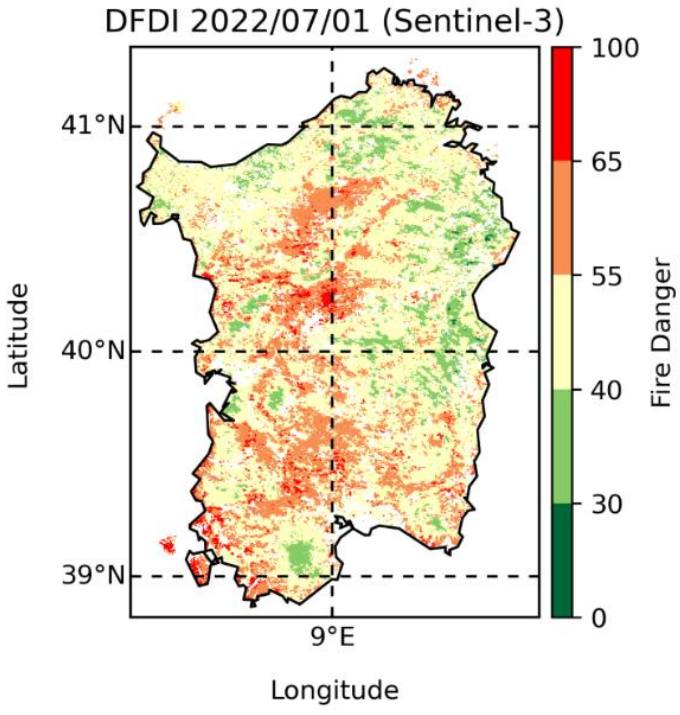
5.2.1. Daily Fire Danger Index, DFDI

Description	The Daily Fire Danger Index is a new fire danger index based on weather data and satellite imagery. In particular, the product relies on the Sentinel-3 SYNERGY product to estimate the state of the vegetation in terms of the amount of available dead vegetation and in terms of the live fuel moisture content. The weather variables are used to calculate the dead fuel moisture content, the evapotranspiration and to obtain the wind speed at 2 metres height. These variables are normalised and weighted using the historical fire records of the area of interest. In addition, the weather forecast data is used to provide a fire danger forecast 1) at different times of the day and 2) for the following days.
Type & format	Geospatial (.tif)
Units	Percentage danger and categorical danger rating: very low danger, low danger, medium danger, high danger, extreme danger.
Update Frequency	Daily
Temporal coverage	Daily
Spatial resolution	300 m
Methodology	The DFDI derives from the tradition of satellite-based fire danger indices that starts from the Burgan's Fire Potential Index (FPI) and culminates with the Italian Daily Fire Hazard Index (DFHI). Differently than other fire danger indices based only on weather information (e.g. the Canadian Forest Fire Weather Index), these indices exploit satellite information to obtain estimates on the state of the vegetation. Originally, the FPI used historical NDVI measurements to calculate the Relative Greenness of a pixel, thus providing an estimate of the amount of dead vegetation present in the area. The DFHI built upon this foundation, and, among other improvements, used Ceccato's Global Vegetation Moisture Index to estimate the Equivalent Water Thickness (EWT) of the canopy, in order to provide a more direct assessment of the water content in the vegetation. However, it is well-known that the EWT is only one of the two variables necessary to calculate the Live Fuel Moisture Content (LFMC) of the vegetation: in order to completely describe the moisture state of a live leaf, it is also necessary to have information about its weight per unit surface in terms of Dry Matter Content (DMC), whose value evolves according to the maturing and curing state of the leaf. The DFDI improves upon the DFHI by using satellite measurements of canopy reflectance to estimate LFMC, and in addition, redefines the index calculation completely in order to incorporate directly the contributions of wind speed, evapotranspiration and of the LFMC itself.
Contact	Valerio Pampanoni, SIA: valerio.pampanoni@uniroma1.it
Publication	[64] Laneve, G., Pampanoni, V., & Uddien Shaik, R. (2020). The Daily Fire Hazard Index: A Fire Danger Rating Method for Mediterranean Areas. *Remote Sensing*, *12*(15), 2356. https://doi.org/10.3390/rs12152356

Copyright © FirEUrisk Consortium. All rights reserved.

Overview

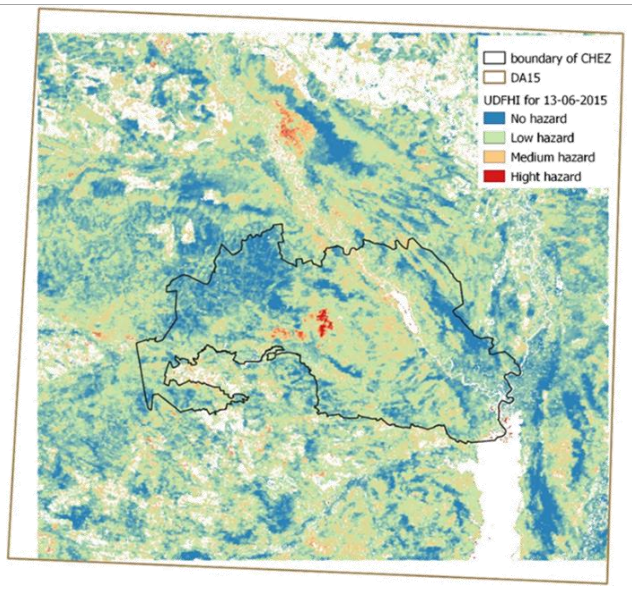




DFDI maps in DA5 Sardinia on May 1st (left) and July 1st (right) 2022

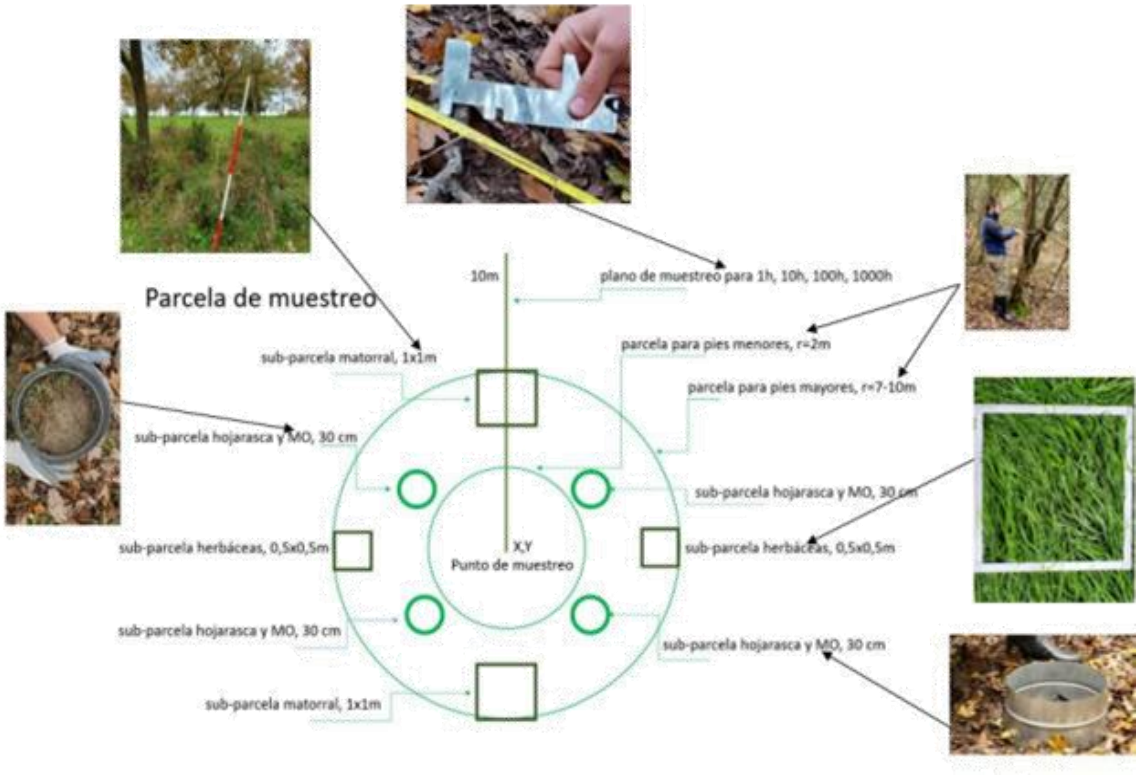
Copyright © FirEUrisk Consortium. All rights reserved.

5.2.2. Fire danger index classification for Chornobyl Exclusion Zone

Description	The Product allows to use outputs from Fire danger index classification for Chornobyl Exclusion Zone.
Type & format	Geospatial (.tif)
Units	Quantitative, %
Update Frequency	Daily
Temporal coverage	2010-2020
Spatial resolution	306 m
Methodology	Remote sensing data were taken for the period 2006-2020 years from March to November (MODIS-based products: MOD09GA and MOD13Q1). Hourly historical meteorological data (relative humidity, temperature, wind speed) were uploaded with the use of NASA API. Extinction moisture content is taken for the exact fuel type taken from Fuel Type Map that was described in REEFMC contribution to A1.1.4. Modified version of Daily Fire Hazard Index (DFHI) provided in Laneve et al., 2020 was modified by adjusting the moisture content in dead fuel according to the field data gathered during 2015-2017 on the territory of CHEZ. For assessing accuracy of UDFHI 1331 fire polygons for the period from 2010 to 2020 years were downloaded in shape format from the repository of MCD64A1 product. Fire polygons were used to build fire density maps in 10 km square cells that cover the entire study area. The assessment was made by comparing average values of the index to fire density in the cells. Averaging fire density values in five percent ranges shows clear correlation of average values of UDFHI and average fire density with coefficient of correlation 0.82.
Contact	Sergiy Zibtsev, REEFMC: sergiy.zibtsev@nubip.edu.ua
Overview	 *Map of UDFHI in DA-15 for June 13th, 2015*

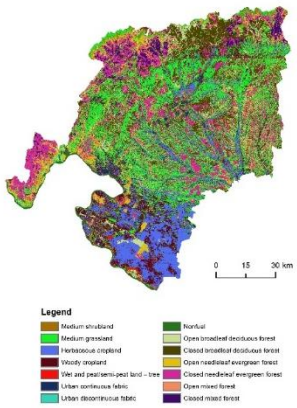
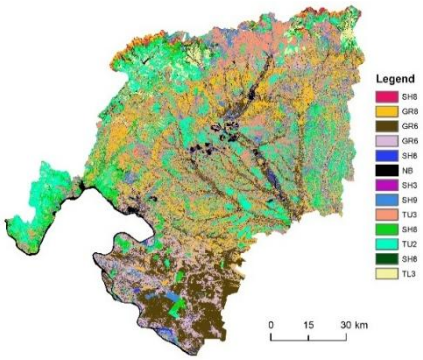
Copyright © FirEUrisk Consortium. All rights reserved.

5.2.3. Custom fuel characterization

Description	A database with the fuel characteristics including dead and live fuel loads for the FirEURisk fuel types in a form of a table with fuel characteristics. Developers implemented the FirEURisk Field Sampling Protocol to get the fuel data.
Type & format	Document (.pdf, .xls)
Temporal coverage	2021
Methodology	The FirEURisk fuel classification includes: (1) Arboreal fuel (canopy height >3m) and FCC>15%; (2) Using the dominant species to differentiate between classes (Evergreens, Deciduous, Angiosperms, Gymnosperms, and mixed forests); (3) Differentiation between open forest (FCC>15%) and closed forest (FCC>70%); (4) Shrub and herbaceous fuel according to the height of the fuel layer; (5) Differentiation between arid and humid according to the Martone Index. The values for fuel typology are used for fire behaviour simulation. Average value specific to the plot using the photo guide. Our contribution is significant for the characterisation of fuels within the framework of the project for the Mediterranean area. It allows us to adapt fuel models for the province of Barcelona and make a comparison with American models (Scott and Burgan, 2005).
Contact	Maria Cristina Vega Garcia, UdL: cristina.vega@udl.cat
Overview	

Copyright © FirEURisk Consortium. All rights reserved.

5.2.4. Fuel type and fuel models map

Description	The product provides the fuel type and parameters following a standard classification of fuels agreed for the project. The final output are fuel classes and static fuel map with the spatial resolution of 1 ha for the Romanian demonstration areas, i.e. Mehedinți and Gorj Counties.
Type & format	Geospatial (.tif)
Units	Categorical: fuel types & fuel models
Update Frequency	Static layer
Spatial resolution	100m (1 ha)
Methodology	To create the fuel types map, multiple datasets were integrated. First, forested areas were extracted from the most recent digital forest maps, developed at the Forest District level. These maps, with a nominal scale of 1:5000, include all forestry parcels (i.e., forest management units) within the study area. Forest fuel types (e.g., broadleaved, needleleaved) were classified based on the species composition of each parcel. Next, to distinguish between open and closed forests, the Copernicus Tree Cover Density dataset was used (Copernicus Tree Cover Density 2018). This pan-European map provides tree cover density values ranging from 0% to 100% at spatial resolutions of 10 m and 100 m, using data from the reference year 2018.The forest management database also supported the mapping of forest roads, buildings, and certain agricultural and pasture lands managed by forestry services. For mapping the remaining fuel classes, the Land Cover Map of Europe [65] was employed. This map, based on Sentinel-2 imagery with a 10 m spatial resolution, enabled the automatic classification of land cover classes. These classes were then matched to the predominantly non-forested fuel types found within the study area. Finally, the fuel models map was generated using the FirEUrisk fuel types crosswalk to the Fire Behavior Fuel Models (FBFM) system, as proposed by Aragoneses et al. (2023) [5]. The accuracy of the fuel maps was evaluated using high-resolution aerial imagery (0.5 m), acquired by the Romanian National Agency for Cadaster and Land Registration between 2018 and 2020. The assessment resulted in an overall accuracy of 86.7%.
Contact	Adrian Lorent, INCDS adrian.lorent@icas.ro
Overview	 a)  b) *Fuel type map (a) and fuel models map (b) for the Romanian Demo area*

Copyright © FirEURisk Consortium. All rights reserved.

5.2.5. Canopy metrics and landscape file

Description	This product contains the raster grids required to generate the different canopy fuel variables as well as terrain condition at 100m and 25m resolution, including Canopy Fuel Weight (CFW, kg/ha), Canopy Bulk Density (CBD, kg/m^3), Canopy Base Height (m), Digital Terrain Model (m), Vehicle Mobility, Slope (degrees), Aspect, Canopy Cover (percentage) and Canopy Height (m). The grids were calculated from LiDAR data using Andersen formulas. This has been developed for the Swedish Pilot Site, i.e. Kalmar County.
Type & format	Geospatial (.tif)
Units	Kg/ha, kg/m^3, m, degrees
Spatial resolution	100m (1 ha) and 25m
Methodology	This section provides description of methodology used to produce above mentioned list of raster grids viz. • Light Detection and Ranging (LiDAR) data provided by FirEUrisk project and LiDAR) observations from the Global Ecosystems Dynamics Investigation (GEDI) sensor were processed by Arbonaut's in-house code ArboLidar to compute Digital Terrain Model (m), Slope (degrees) and Aspect. • The ArboLiDAR code has tool called "CHM tool" that creates a raster from LiDAR points based on proximity to pixels and other criteria. The same tool is also used to calculate Slope (degrees) and Aspect. Holes (NoData pixels) and pits (low-value pixels) are filled using a context-based approach, replacing pit values with a filtered height raster for smoother results. • Canopy Fuel Weight (CFW, kg/ha), Canopy Bulk Density (CBD, kg/m^3) and Canopy Base Height (m) were estimated with models provided in Andersen et al. (2005) [66]. Following formulae were used to compute $\sqrt{\text{Canopy Fuel Weight}} = 22.7 + (2.9)h_{25} + (-1.7)h_{90} + (106.6)D$ $ln(\text{Canopy Bulk Density}) = -4.3 + (3.2)h_{cv} + (0.02)h_{10} + (0.13)h_{10} + (0.12)h_{90} + (2.4)D$ $\text{Canopy Base Height} = 3.2 + (19.3)h_{cv} + (0.7)h_{25} + (2.0)h_{50} + (-1.8)h_{75} + (-8.8)D$ Here, h_{cv} is coefficient of variation of the lidar heights h_{25} is 25th percentile height h_{50} is 50th percentile height h_{75} is 75th percentile height D is the Canopy density metric (percentage of first returns within the canopy)
Contact	Tuomo Vuorenpää, Arbonaut: tuomo.vuorenpaa@arbonaut.com
Overview	

Copyright © FirEUrisk Consortium. All rights reserved.

5.2.6. Spring grass fire model for the North Europe

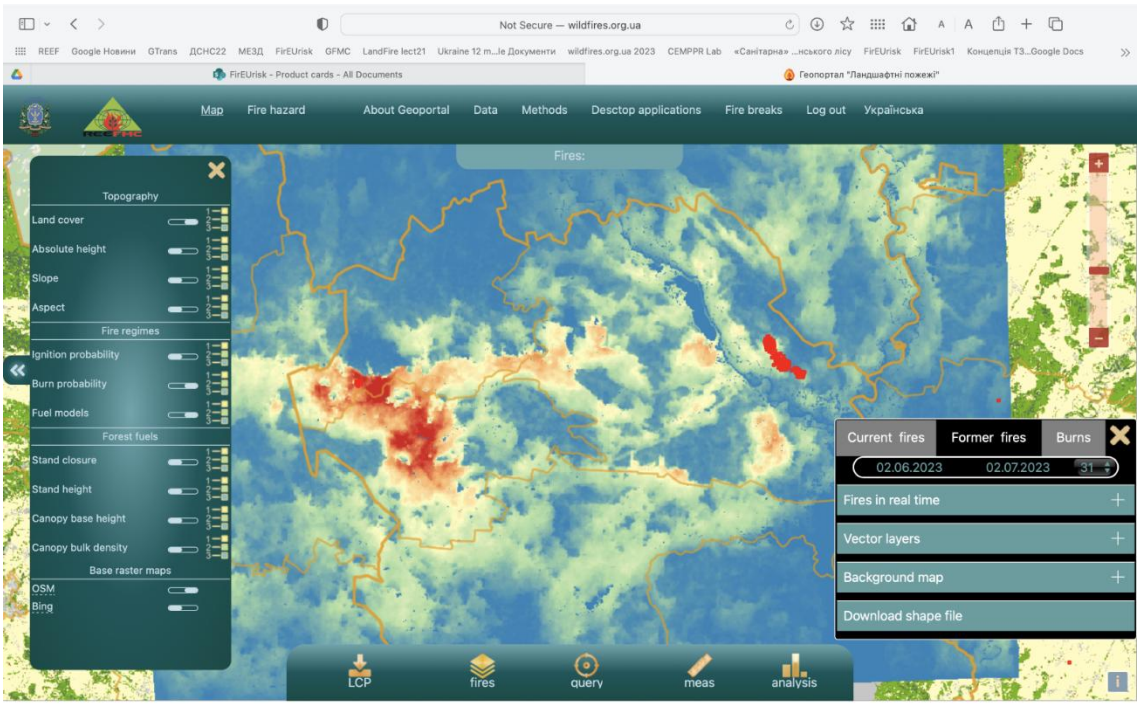
Description	This product is a fire danger model for North spring grasslands that produces fire danger maps with hourly temporal resolution.
Type & format	Geospatial (.tif) and model
Units	Categorical : fire danger classes
Update Frequency	Hourly
Temporal coverage	Forecast for a five days. Model based on 1996-2021
Spatial resolution	2.5 km
Methodology	The fire danger model is based on (1) 25 years of dispatch statistics in Sweden; (2) Series of grassfire experimental burns during a whole season; (3) Field inventory of grasslands to develop phenological model. In regions with cold winters (North America, Scandinavia, Eastern Europe, Russia) the fire danger of grass fuels is very high just after the winter where usually 100 % cured grass litter is very flammable after just a few hours exposure to dry air and sun light. As the spring progresses, fresh green grass grows within the litter and brings high amounts of moisture to the fuel bed, reducing spread rates and intensity until practically arrested spread at beginning of summer, even during dry conditions. The model takes into account dead fuel moisture and thus needs input on the following parameters on an hourly basis: past precipitation (mm/h), relative humidity (2-m), temperature (2-m), wind speed (10-m open ground), solar irradiation, daily average air temperature, and snow cover. The model also takes into account the local wind speed for Rate of spread and the contribution from green-up of this season's grass using a phenological model. Unlike forest fire danger for which fireline intensity is the danger metric, the danger levels are determined based on the rate of spread, the most challenging part of grassland fires. The model is operational in Sweden since 2021 but could be applied also to other regions with cold winters.
Contact	Johan Sjöström, RISE: johan.sjostrom@ri.se
Publication	[67] Sjöström Johan, Granström Anders (2023) A phenology-driven fire danger index for northern grasslands. International Journal of Wildland Fire 32, 1332-1346 https://doi.org/10.1071/WF23013
Overview	

Copyright © FirEURisk Consortium. All rights reserved.

5.2.7. DSS ChEZ REEFMC

Description	This product assesses fire danger using existing danger indices and drought codes as well as radioactive dose prediction during wildfires. Those data will be available in a free and open platform based upon the internal cooperative platform as the one-stop-shop for data, models and knowledge on fire risk in ChEZ (www.wildfires.org.ua)
Type & format	Geospatial (.Tif)
Units	Pixels/ radionuclides / doses / type of fuel
Update Frequency	Up to request
Estimated Accuracy	100 m
Temporal coverage	2000-2022
Spatial resolution	30 m
Methodology	The LANDSCAPE FIRE information system was designed to support fire spread modelling approach specifically incorporated in FlamMap [68], FARSITE [45] and other fire simulation software. Based on different types of spatial and non-spatial data used in this software. Landsat-based land cover map [69] allows to identify primary land cover and assign to each pixel a surface fuel model [70], fuel load and potential fire behaviour. For the crown fuels used Global Forest Change data [71] to extract canopy cover for 2015 and Geoscience Laser Altimeter System (GLAS) canopy height (RH100) global model [72] to map forest stands height. Another two canopy fuels characteristics namely canopy base height and canopy bulk density were derived using Random Forest (RF) regression model [73] applied to the same Landsat 8 OLI data (summer, autumn, and April-October 2014–2016 cloud-free mosaics) previously introduced for land cover classification [69]. As input variables for canopy base height (CBH) mapping, we selected greenness, brightness, wetness Tesseled-Cap Transformation [74] bands; median, first and third quartiles of Normalized Difference Vegetation Index (NDVI). These predictors accompanied with GFC canopy cover, RH100 canopy height, and groups of forest stands (coniferous, deciduous, mixed) presented on land cover classification were used to predict canopy bulk density (CBD). We used Forest Vegetation Simulator to calculate CBH and CBD (in $kg \cdot m^{-3}$) for selected from forest inventory database forest stands and use these data as reference in our regression model. Monthly fuel moisture was adjusted for each type of surface fuel models, so that it replicates annual variation of live and dead fuel moisture content and ensure reasonable speed of fire spread under different weather scenarios. For topography and weather, we used 90-meters spatial resolution Shuttle Radar Topography Mission (SRTM) digital elevation model that covers ChEZ. All spatial layers were prepared using Google Earth Engine (GEE) cloud-based platform which accelerate data processing [75]. The raster maps were projected into EPSG: 3857 coordinate reference system and then resampled to common 90-meters spatial resolution using nearest neighbors' algorithm. Seasonal pattern of wind maximum speed and its direction were derived from the Ukrainian State Hydrometeorological Service for 2004–2010 registered on 23 weather stations distributed within the study area. The ignition history for the study area was collected for 2001–2019 based on MODIS (MOD/MYD14) daily thermal anomalies data. We grouped ignitions pixels for every day, so they represented distinct fires. Then centroids were identified for each of them to create smoothed ignition probability grid using kernel

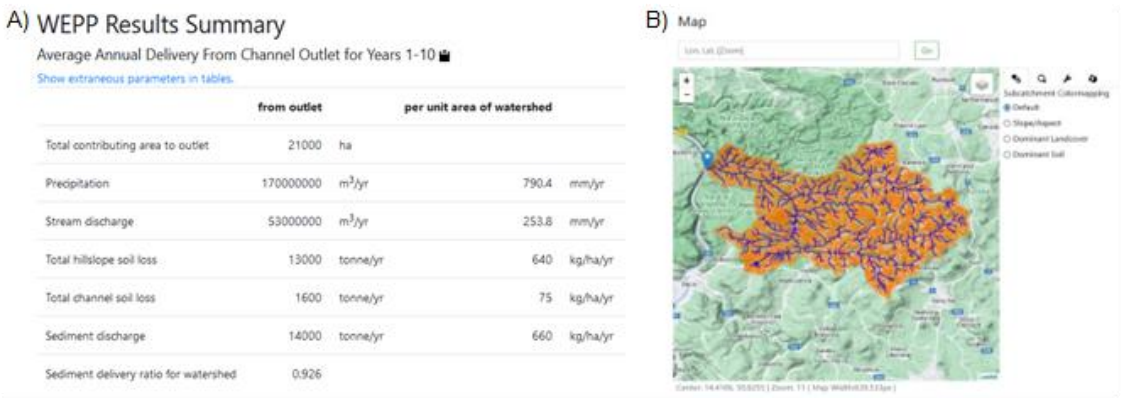
Copyright © FirEUrisk Consortium. All rights reserved.

	density function in Quantum GIS with search radius of 15 km. After all data were uploaded, we tested the efficiency of web-based tools for wildfire simulation. We simulated early phase of large wildfire started near the Chernobyl Exclusion Zone on April 3, 2020 and burned within 3 weeks totally more than 64 thousand hectares. We used FARSITE 4 built within FlamMap 6.1 to model first 24 hours of burning using coordinates of ignition identified from MOD/MYD14 data and hourly weather (air temperature, relative humidity, precipitation, wind speed, and wind direction). Submodules of calculation of the expected 1-hour dose of radionuclides for firefighters on fireline, strategic location of fire engines during emergency fire weather, optimal routing for heavy and light fire engines, monitoring of fire development and others implemented in the portal. Later large fire in 2020 in Luhansk Oblast with area 37 000 ha was also simulated within the platform. For the moment platform used to collect data on fire history during war.
Contact	Sergiy Zibtsev, REEFMC: sergiy.zibtsev@nubip.edu.ua
Publication	ChEZ website: www.wildfires.org.ua
Overview	

Copyright © FirEUrisk Consortium. All rights reserved.

5.3. Exposure products

5.3.1. WEPPcloud-EU-WATAR

Description	The product is a probabilistic runoff and erosion model designed for quantification of post-fire soil, ash, water, nutrient, carbon and pollutant transport from burned hillslopes into stream channels and water bodies for a given burn area and fire severity.
Type & format	Geospatial (open-access online interface)
Units	kg/ha, tonne/yr
Temporal coverage	Applicable to actual or potential fires
Spatial resolution	25 m
Methodology	The model automatically accesses and processes specific European datasets for the required input data (climate, topography, soil type, land use and ash chemical composition), limiting input data from the end-user and simplifying its application. The only external input required by the model is a burn severity map, which end-users can develop from satellite images according to Parsons et al. (2010) [76]. Detailed description of model capabilities and data sources are available in Neris et al. (2021) [77] Ash composition data is based on Sanchez-Garcia et al. (2023) [78], but this can also be user defined. Validation of the model is in progress. The underpinning erosion model has been extensively validated for US scenarios that are, in general, comparable to their European counterparts. This assures adequate levels of accuracy in its present form, but when we anticipate an increase in this metric after the ongoing validation and calibration process.
Contact	Stefan Doerr, SU: s.doerr@swansea.ac.uk
Publication	The model can be accessed here: https://wepp.cloud/weppcloud/ and then clicking on 'Start EU WEPPcloud-Disturbed Run'
Overview	

A) WEPP Results Summary

Average Annual Delivery From Channel Outlet for Years 1-10

Show extraneous parameters in tables.

	from outlet		per unit area of watershed	
Total contributing area to outlet	21000	ha		
Precipitation	170000000	m^3/yr	790.4	mm/yr
Stream discharge	53000000	m^3/yr	253.8	mm/yr
Total hillslope soil loss	13000	tonne/yr	640	kg/ha/yr
Total channel soil loss	1600	tonne/yr	75	kg/ha/yr
Sediment discharge	14000	tonne/yr	660	kg/ha/yr
Sediment delivery ratio for watershed	0.926			

B) Map

A) Example of the WEPPcloud-EU-WATAR model results, and B) Sub-catchment delineation for the area partially affected by the 2022 Bad Schandau fire (Central Europe Pilot Site).

Copyright © FirEURisk Consortium. All rights reserved.

5.3.2. Forecast of health-impacts of wildfire-smoke

Description	This product provides forecasts of local hospital-admissions due to exposure to wildfire smoke during a given wildfire. The AirQ+ methodology from the World Health Organization (WHO) will be followed. The final output will be the expected rise in number of hospital admissions due to a wildfire smoke episode at a resolution on the order of 1 km
Type & format	Geospatial (.shp, .tif)
Units	Number of hospital admission
Update Frequency	Near-real time after wildfire ignition
Estimated Accuracy	The AirQ+ methodology will be trusted. The accuracy of the air-pollutant concentrations from the smoke dispersion forecast will be a defining factor in the quality of the results.
Temporal coverage	Fire duration
Spatial resolution	~1km
Methodology	The AirQ+ methodology from the WHO requires the smoke dispersion forecast at local scale and the population geographical distribution (if possible, including location of firefighters) and health indicators. 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). The output can serve as an indicator of population exposure to smoke for decision makers.
Contact	Ana Isabel Couto Neto da Silva Miranda, UAVR: miranda@ua.pt

5.3.3. Geospatial integrated eruptive fire risk map and merging fires risk map

Description	The product allows to use outputs from dynamic on-line calculation of eruptive fire risk map and detection of merging fires shown on risk maps based on geospatial calculations using fire propagation simulator where simulations with 2 ignition points could be started.
Type & format	Geospatial (.tif)
Update Frequency	1 year
Estimated Accuracy	to be defined
Temporal coverage	2 times per day
Spatial resolution	100 m
Methodology	In our existing system used by Croatian firefighters there is a part dedicated to predict regions with potential eruptive fire danger. Beside that we could share our experiences with other partners and that we can offer our methodology used in on-line tool for detect eruptive fire zones through FirEURisk project we would like to improve our tool based on other partners experience as well as to extend it

Copyright © FirEURisk Consortium. All rights reserved.

	potential detection of other extreme fire behaviour. For us maybe the most interesting are merging fires. Big firefighter accident at Kornati islands was caused partly by such effect.
Contact	Darko Stipanicev, FESB SPLIT: dstip@fesb.hr

Copyright © FirEUrisk Consortium. All rights reserved.

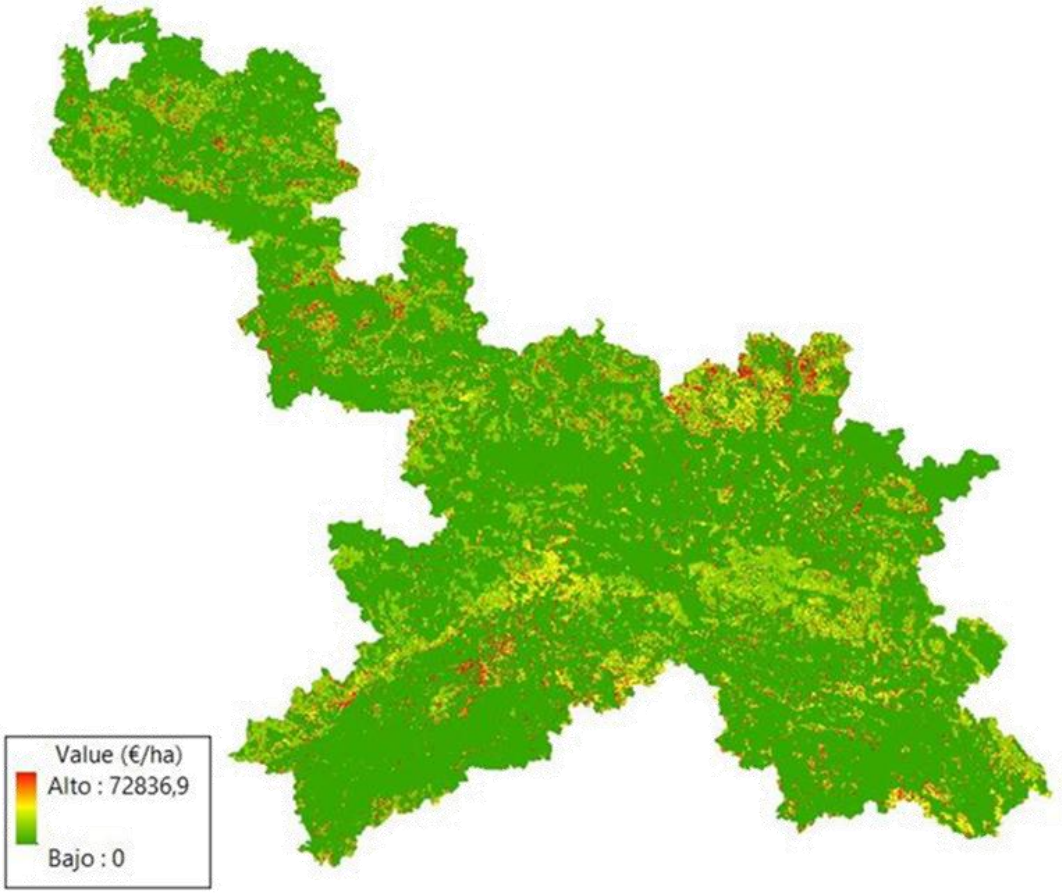
5.4. Vulnerability products

5.4.1. Potential Losses on Ecosystem Services affected by wildfires

Description	the System for the Economic Evaluation of Forest Fires (SEVEIF) is a quantitative map estimated from the net value change using the environmental services assessment and the potential fire behaviour. The potential economic losses have a spatial resolution of 100m and 1km.
Type & format	Geospatial (.tif)
Units	€/ha (product at 100m of spatial resolution) €/km^2 (product at 1km of spatial resolution)
Update Frequency	Static layer
Estimated Accuracy	80%-90%
Temporal coverage	Dependent on pilot site data availability
Spatial resolution	100m/1km
Methodology	This product estimates the potential fire impacts based on the integration of economic valuation of natural resources and the potential fire impacts. The net value change (NVC) t is determined by the resources value and the potential fire intensity level (FIL). The methodological framework includes a depreciation matrix for each environmental service of our territory based on the potential FIL. A detailed description of the algorithms and data sources is available in the following deliverable: 1.6 - On-line methodological handbook for socio-economic assessment of fire impacts/damages. https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5f9c08ae0&appId=PPGMS
Contact	Juan Ramón Molina, UCO: jrmolina@uco.es
Publication	[66] M. Ortega, A. L. Sancho and J. R. Molina, "Visual-SEVEIF: a tool for economic planning on wildfire decision-making," 2023 8th International Conference on Smart and Sustainable Technologies (SpliTech), Split/Bol, Croatia, 2023, pp. 1-7, doi: 10.23919/SpliTech58164.2023.10193546.

Copyright © FirEURisk Consortium. All rights reserved.

Overview



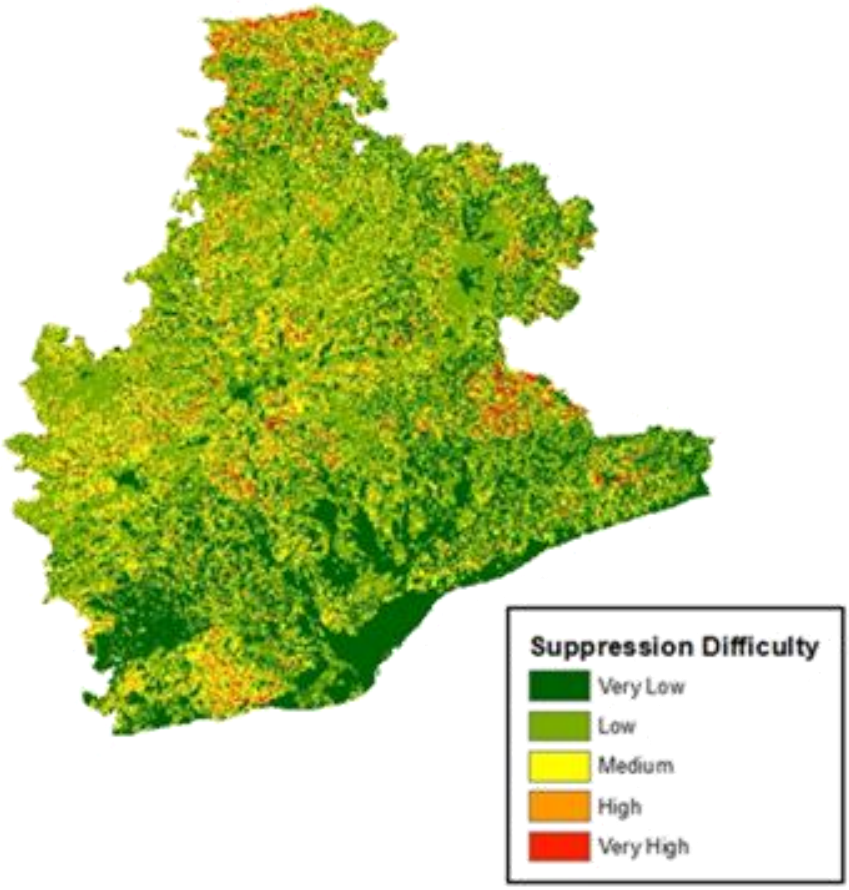
Economic losses in Central Europe (PS2).

Copyright © FirEURisk Consortium. All rights reserved.

5.4.2. Suppression Difficulty Index Evaluation

Description	It is a qualitative map focus on a family of such tools designed to characterise the difficulty of suppression operations by weighing suppression challenges against suppression opportunities. These tools integrate potential fire behaviour, vegetation cover types, topography, road and trail networks, existing fuel breaks and fireline production potential to map the operational effort necessary for fire suppression.
Type & format	Geospatial (.tif)
Units	Qualitative difficulty (1 = Very Low, 2 = Low, 3 = Medium, 4 = High, 5 = Very High)
Update Frequency	Static layer
Estimated Accuracy	80%-90%
Temporal coverage	2021
Spatial resolution	100m
Methodology	The Suppression Difficulty Index (SDI) algorithm is calculated as potential fire behaviour, represented as the surface fire energy behaviour sub-index, divided by suppression opportunity index, calculated as the sum of sub-indices for accessibility, mobility, penetrability, aerial resources and fireline construction rate. The SDI is a multicriteria evaluation tool developed by a former incident commander with more than 25 years of wildfire experience that relies on expert judgement to rescale all sub-index values from 1 to 10 and combines them into an overall dimensionless index where higher values indicate higher suppression difficulty. Detailed description of algorithm of calculation and data sources available here: https://research.fs.usda.gov/treesearch/60002
Contact	Juan Ramón Molina, UCO: jrmolina@uco.es
Publication	[67] Rodriguez y Silva, Francisco; O'Connor, Christopher D.; Thompson, Matthew P.; Martinez, Juan Ramon Molina; Calkin, David E. 2020. Modelling suppression difficulty: Current and future applications. International Journal of Wildland Fire. doi: 10.1071/WF19042.

Copyright © FirEURisk Consortium. All rights reserved.

Overview	 *Suppression difficulty index in Barcelona pilot site.*

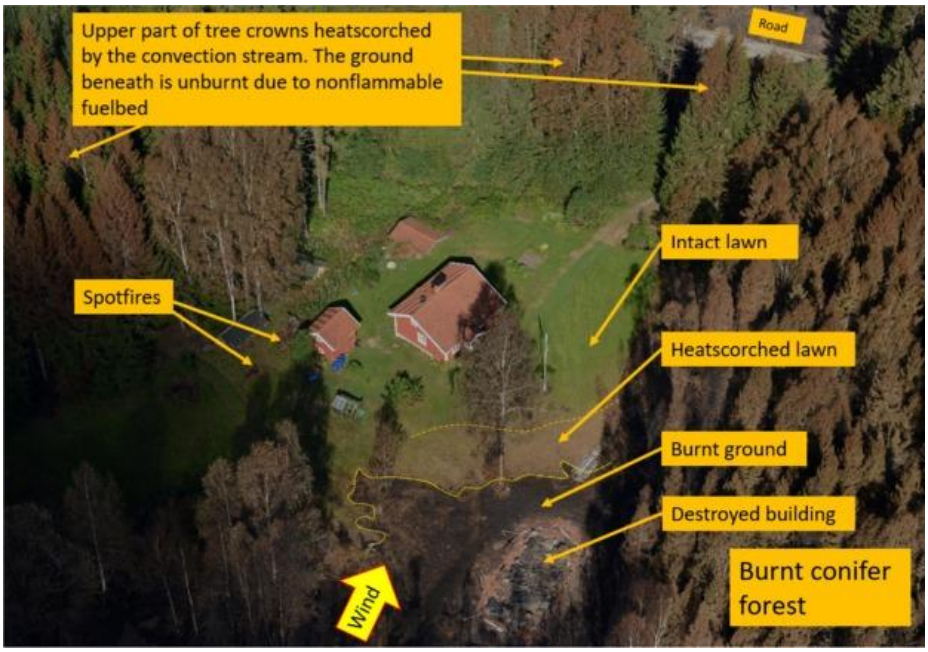
5.5. Risk mitigation and reduction products

5.5.1. Guidelines for citizens involvement in wildfire risk reduction

Description	The Product is a guidelines on how to design and implement engagement strategies for 'citizen-scientists' networks, including the development of training materials.
Type & format	Document (.pdf)
Methodology	To participate in Elaboration of Guidelines on how to design and implement engagement strategies for 'citizen-scientists' networks, including the development of training materials. Our contribution will be to prepare training materials in Croatian for 'citizen-scientist' networks.
Contact	Darko Stipanicev, FESB SPLIT: dstip@fesb.hr
Publication	Brochure will upload on FirEURisk platform

Copyright © FirEURisk Consortium. All rights reserved.

5.5.2. Factors for building survivability in Scandinavia

Description	This product describes list of importance of factors for building survivability in large forest fires in Scandinavia
Type & format	Document (.pdf)
Methodology	The factors critical for building survival in Scandinavian are assessed by a field inventory on all buildings that were within the perimeter of four forest fires in Sweden 2014 and 2018. The inventory encompassed 187 buildings and their status, management, garden structure and surroundings prior to the fire was assessed in relation to the post fire damages. It was clear that garden structure was most important for survivability and that the three most important factors (statistically significant) were (1) a managed lawn around the building, (2) reduced residential or vegetation fuel in direct contact to the facade and (3) inclusion of deciduous trees around the garden. The factors are also the most important ones from a study of small vegetation fires igniting buildings in Sweden (approx ~600 ignitions).
Contact	Johan Sjöström, RISE: johan.sjostrom@ri.se
Publication	[81] Plathner, F. V., Sjöström, J., & Granström, A. (2023). Garden structure is critical for building survival in northern forest fires–An analysis using large Swedish wildfires. Safety science, 157, https://doi.org/10.1016/j.ssci.2022.105928.
Overview	 *An example from the Västmanland fire in which the maintained lawn prevented the fire to be carried to the buildings. The fire, traveling upwards in the figure, had a moderate to high intensity as it reached the property. It destroyed two buildings, of which the remains of one is seen in the low, center part of the figure. Hot convection streams scorched the upper parts of the spruce and birch trees in the background. However, the lawn and everything located on the lawn, such as buildings, plastic water barrels and woodpiles, were unaffected by the fire. Photo: Swedish armed forces' helicopter wing (with permission).*

Copyright © FirEUrisk Consortium. All rights reserved.

5.6. Adaptation products

5.6.1. Fire risk and strength predictions: short-term & long-term

Description	A gridded product of regional-scale resolution predicting the distribution of fires and their strength at a time scale of (i) a few days, (ii) long-term scenarios, past and future over the EU territory.
Type & format	Geospatial (.nc)
Units	MW
Update Frequency	Short-term: daily. Long-term: static dataset
Estimated Accuracy	Spatially: fire distribution localization within the region of 3°´3° and temporally within one day. Temporal correlation coefficient with daily MODIS Fire Radiative Power product is R = 0.1 – 0.6 depending on continent and land-use type.
Temporal coverage	As long as meteorological data are available
Spatial resolution	3° temporal prediction downscaled to 0.1°
Methodology	The methodology is presented in a series of open-access papers, therefore only its general outline is provided. For the details, the reader is referred to the quoted publications. We also do not go into technicalities of the methodological adaptations to peculiarities of the fire prediction task. These will be presented in a series of new papers, presently in preparation, where both the approach and the obtained datasets will be described in-depth. The statistical methodology adapted to fire forecasting has its roots in the ground-setting works of Voeikov Main Geophysical Observatory for urban air pollution [82]. This methodology has been adapted by the FMI team to a wide variety of tasks, such as prediction of pollen concentrations in the air [83], inter-annual variations of birch flowering intensity [84], personalized allergy symptoms forecasting for sensitive individuals [85], (Sozinova et al, in prep), and, with deeper modifications, to multi-model ensemble forecasting (Sofiev et al, in prep.). A common methodological difficulty of vast majority of statistical models is stringent requirements to features of the analysed data: (i) the least-square-error and correlation quality criteria are justified only for normally distributed stochastic processes uncorrelated with predictors and predicted variable (additive noise); (ii) averaging- and correlation- based methods require the processes to be stationary and ergodic, so that the averaging over a statistical ensemble of realizations can be substituted with averaging over time or space; (iii) (multi-) linear regressions imply linear dependencies of the predicted quantity and independent predictors. None of these assumptions is fulfilled in case of fires, not even approximately. Indeed, the mere existence of the start and the end of the fire season makes the process both non-stationary and non-ergodic at annual level. At multi-annual level, the situation is somewhat better but even then the distribution function of FRP remains very far from normal: e.g., all percentiles up to 95%-99% are zero. The only data transformation applied in the literature to non-classical datasets is the log-transform of the predicted variable and, possibly, predictors, e.g. [86], [87] as a precaution against log-normally distributed

Copyright © FirEURisk Consortium. All rights reserved.

data. Other difficulties have not been considered in the studies we are aware of. This transformation however is inapplicable to fire models because they are supposed to predict zeroes most of the time.

The above-quoted methodology has a proven record of handling problems with similar difficulties. However, the statistical features of the fire problem represent an extreme case.

The current study aims to construct a local statistical forecasting model that takes the above peculiarities of the fire time series into account. The objective is to predict the daily total release of fire radiative energy using only basic meteorological parameters.

The core of the predicting model is a quite standard multi-linear optimization problem but with several regularization mechanisms. The core of the approach is under development within the CAMS-63 research project of Copernicus, with which EXHAUSTION shares the low-level background optimization modules. The family of multi-linear models that serves as the starting point for FFM is described as follows (Sofiev et al, 2020, CAMS-63 progress report):

(1)
$$J(t,\tau) = \frac{1}{O}\sum_{o=1}^{O} \frac{(c_{opt}(i_o,j_o,k_o,t,\tau,A) - c_o(t))^2}{c_o^{n1}(t)} + \alpha \sum_{m=1}^{M} |a_m(\tau)|^{n2} + \beta \sum_{m=1}^{M} |a_m(\tau-1) - a_m(\tau)|^{n3}$$

$$\tau = \{d_{-k} \ldots d_0\}, \quad n1 \in \{0,1,2\}, \quad n2 \in \{0,1,2,\ldots\}, \quad n3 \in \{0,1,2,\ \ldots\}, \quad A = \{a_1 .. a_M\}$$

$$c_{opt}(i_o,j_o,k_o,t,\tau,A) = a_0 + \sum_{m=1}^{M} a_m(\tau)\, c_m(i_o,j_o,k_o,t,\tau)$$

In Eq.(1), c_{opt} is optimal prediction of the output variable, FRP in the current case in the corresponding grid cell (i_o,j_o,k_o) and time moment t; the forecast made t days ago, A is vector of optimal coefficients $a_m(t)$ for M predictors and bias correction term a_0, O is number of observations c_o, scaling coefficients a and b decide the weights of the regularization terms and powers $n1$, $n2$, $n3$ decide the shape of the normalization of the error term, strength of the Tikhonov-type regularisation, and low-pass filter, respectively. The minimisation takes the data from k days d_{-1}…d_{-k}.

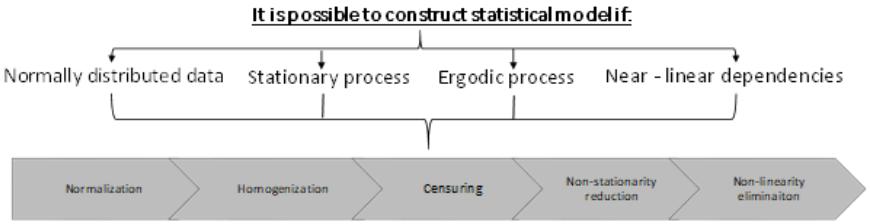
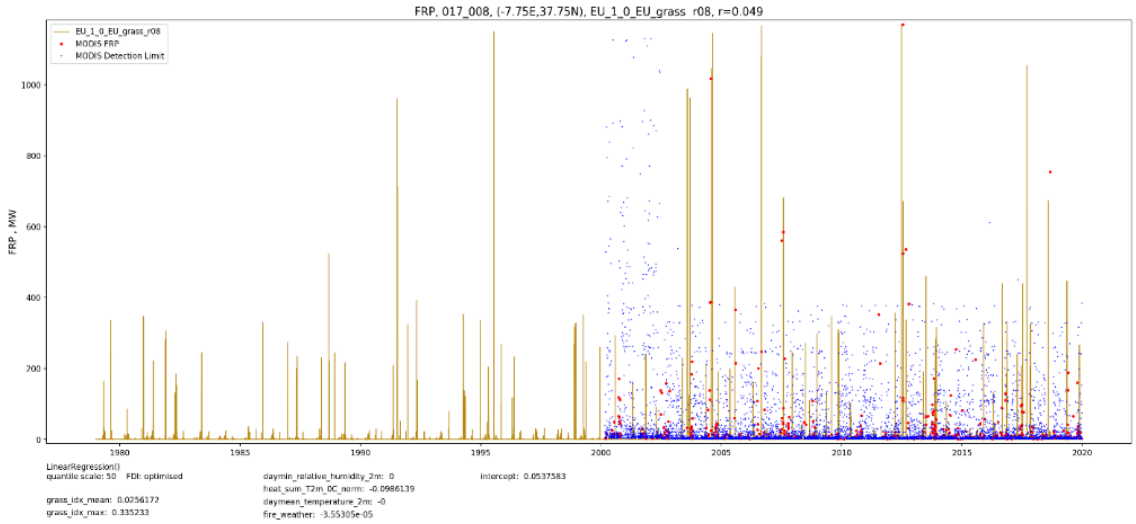
The family of the methods described by Eq. (1) includes:

i. standard least-squares solution MLR if a=b=$n1$=0
ii. normalized least-squares solution if a=b=0, $n1$=2
iii. method H-mult suggested by Galperin and Sofiev, 1994 as a robust alternative to the first two methods if a=b=0, $n1$=1,
iv. Tikhonov-type regularized least-square solution if a>0, b=$n1$=0, $n2$=2, also called as Ridge scheme in textbooks
v. A more rigid version of the regularised least-square solution if a>0, b=$n1$=0, $n2$=1, also called as Lasso scheme
vi. Least-square solution with smooth variation of the coefficients a=n1=0, b>0, n3=2
vii. and so on…

Experiments with the fire prediction problem suggested that the most-efficient optimisation step is a combination of regularised Ridge and Lasso schemes with automated selection of the regularisation efficiency and a fallback option of ordinary MLR for the case of low or no regularization is needed.

The family of optimisation models (1) decides on the input requirements to the data, which are standard for least-square methods. Therefore, the problem, as in earlier FMI and MGO studies, is reduced down to

Copyright © FirEURisk Consortium. All rights reserved.

	transforming the predictors and predicted time series so that they at least approximately satisfy the basic assumptions behind the problem (1). The idea of the approach is to involve a series of transformations of the input data in order to remove of reduce the effect of the above difficulties one by one. The procedure of Ritenberga et al., 2016 [83], included 5 steps enforcing the key assumptions behind the multi-linear optimisation.  *Scheme of the input data pre-processing used by Ritenberga et al., 2016 [83]*
Contact	Sofiev Mikhail, FMI: Mikhail.Sofiev@fmi.fi
Overview	

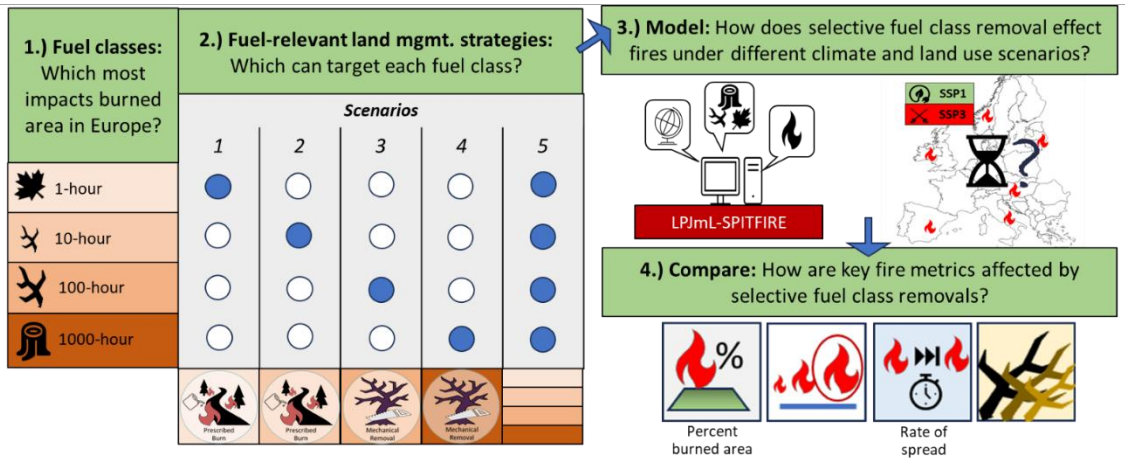
Copyright © FirEURisk Consortium. All rights reserved.

5.6.2. Effective adaptation to changed future fire regimes

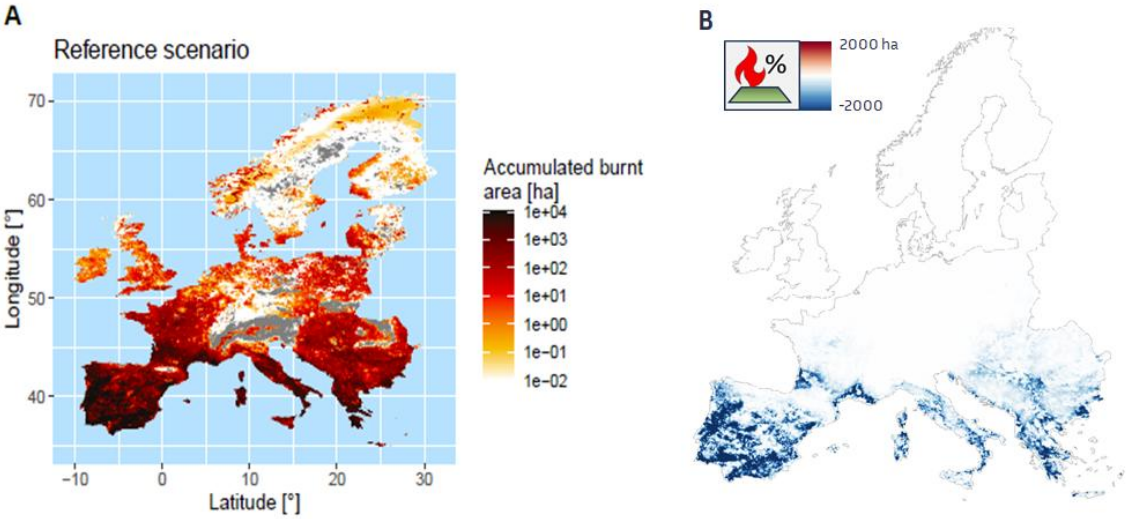
Description	The maps developed for this product in Deliverable 3.7 show simulations of five fuel management strategies on future burned area, maximum surface fire intensity, rate of spread, and fuel bulk density under different climate and land use change scenarios in Europe.
Type & format	Geospatial (.tif)
Units	Variable dependent
Temporal coverage	2020-2050
Spatial resolution	9 km
Methodology	Fuel management schemes were first developed to target fuels as they are structured in LPJmLv5.6-SPITFIRE. In this Dynamic Global Vegetation Model (DGVM), live and dead fuels are distinguished by the length of time needed to consume the fuel by fire, i.e., between 1- and 1000-hours (Figure 3.1, below). The fuel management schemes devised can be associated with land management strategies which typically affect a particular fuel class. Prescribed burn, for example, targets fine fuels, e.g., to 1-hr fuels, while mechanical removal largely targets coarser fuels, e.g., 1000-hr fuels. The effects of each of the fuel removal scenarios on cumulative burned area, maximum surface fire intensity, rate of spread, and fuel bulk density within the study period (2025-2050) under two socioeconomic scenarios (i.e., Shared Socioeconomic Pathway 1, "Taking the Green Road" and SSP3 "Regional Rivalry" which align with the Representative Concentration Pathways RCP2.6 and RCP7.0 are reported.
Contact	Kirsten Thonicke, PIK: Kirsten.Thonicke@pik-potsdam.de Alex Neidermeier, VUA: a.neidermeier@vu.nl
Publication	Deliverables D2.3 "Guidelines for Land Management Strategies: Applicability, socioeconomics and environmental concern", D3.2 "Continental land-use change scenarios and stylised fuel management scenarios for the 21st century", D3.3 "Improved fire regime simulations using hybrid functions in fire models and in fire-enabled DGVMs", and D3.4 "Simulated fire and vegetation dynamics at three spatialscales". Results are currently in preparation for journal submission (Neidermeier et al., in prep).

Copyright © FirEURisk Consortium. All rights reserved.

Overview



Graphical Abstract. Overview of the research organisation and outputs. Left: Scenarios are designed around four fuel classes (left column) which can be related to fuel management strategies (bottom row—prescribed burn and mechanical removal). The scenarios are processed using LPJmL-SPITFIRE, a fire-enabled Dynamic Global Vegetation Model. Four outputs are then evaluated to understand the effects of the fuel management interventions on burned area, fire intensity, surface fire rate of spread, and fuel bulk density for the European Territory.

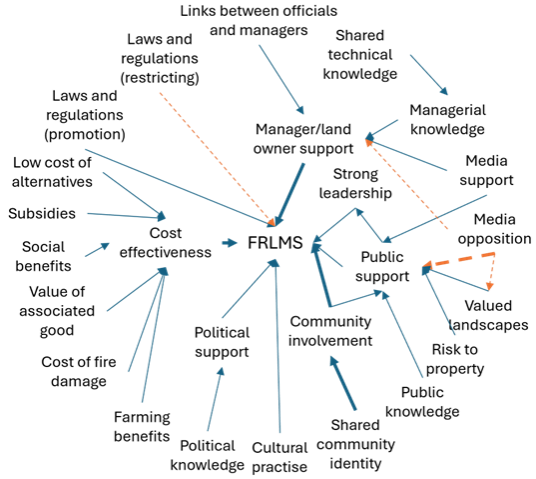


(A) Simulated area burnt [ha] accumulated over the simulation time period 2025-2050 under climate (RCP2.6) and land use (SSP1) change scenarios without effect of fuel management or fire suppression. (B) Effect of fuel removal scenarios (all fuel scenarios combined) under the same scenario combination (SSP1-RCP2.6) on 2025-2050 accumulated burned area [ha].

Copyright © FirEURisk Consortium. All rights reserved.

5.7. Instrumental products

5.7.1. Analysis of potential socio-economic barriers, constrains and enables of Land Management Strategies uptake to reduce fire risk

Description	The product identifies and analyses the socio-economic barriers and constrains to LMS uptake. This involves collecting through specialized literature and consultation with stakeholders and develop economic evaluation models (cost effectiveness analysis) to demonstrate feasibility of interventions to reduce the constraints (like subsidies and regulation).
Type & format	Document (.pdf)
Methodology	We use Fuzzy Cognitive Mapping, underpinned by literature review and expert consultation, to explore alternative socioeconomic interventions to reduce wildfire risk through changes to fuel-relevant land management. We used three European case study sites: 1) Province of Barcelona (Spain), 2) Regions of Coimbra and Leiria (Portugal), and 3) Kalmar County (Sweden). Through the literature review we identified relationships between socioeconomic factors impacting the successful implementation of fuel-relevant land management strategies to create a draft conceptual model. The model was then refined by experts through semi-structured discussions, and online consultation. We tested alternative policy scenarios of: a) increased manager/land owner support; b) improved cost-effectiveness; and c) effective laws and regulations, to compare impacts on fuel-relevant land management strategy implementation. Detailed description of algorithm of calculation and data sources available here: D2.3 "Guideguidelolines for Land Management Strategies (LMS): Applicability, socio-economics and environmental concerns"
Contact	Michaela Roberts, HUTTON: Michaela.Roberts@hutton.ac.uk
Overview	 *Fuzzy cognitive map (FCM) for Spanish case study. Blue solid arrow = positive relationships, orange dashed arrow = negative relationships. Line thickness indicates strength of connections, a narrow line indicating a connection of 0.5, and a thick line a connection of 1. Arrow direction indicates direction of impact (e.g., cost effectiveness impacts land management strategies). FRLMS = Fuel-relevant land management strategy*

Copyright © FirEURisk Consortium. All rights reserved.

5.7.2. Citizens/scientist network and Engagement Plan

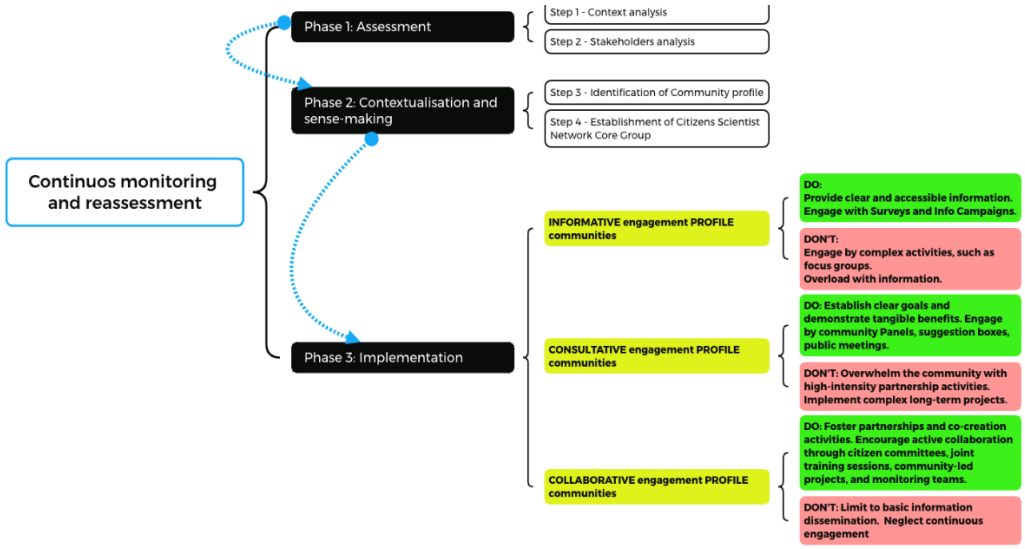
Description	This product proposes a structured framework to involve local communities and stakeholders in wildfire risk reduction strategies and activities, to enhance preparedness and mitigation efforts. The citizens-scientist networks and their dedicated Engagement Plans are the direct result of the implementation of the FirEUrisk Participatory model – a model supporting the establishment of multi-stakeholder partnership at local level for the purpose of enriching and strengthening existing fire risk management processes with local knowledge and capabilities. Citizen-scientist networks serve as a bridge between local communities and scientific research, enabling a collaborative approach to data collection, validation, and outreach. This model fosters trust between local actors and researchers while empowering communities with knowledge and decision-making capabilities in fire risk management processes. The framework includes: • Assessing the local context both in terms of social variables and in terms of overall propensity towards participation and awareness and perception with regards to the wildfire risk • Identifying the predominant profile of the community at stake according to three main typologies main (i.e., Informative Engagement Communities, Consultative Engagement Communities, and Collaborative Engagement Communities). • Mapping the most relevant stakeholders to be engaged at local level in order to establish the Citizens-Scientists Network (CSN). • Developing context-specific engagement plans making use of multi-channel and two-ways communication, as well as tailoring culturally relevant messaging and collaboration with local authorities
Type & format	Document (.pdf)
Methodology	To support the establishment of Citizens-Scientists networks at local level, the FirEUrisk Participatory model is proposed as follows: • A Conceptual Framework (i.e., Resilience Ecosystem) – allowing for the visualization of the components of the overall resilience processes within a specific context. The Conceptual framework builds on, and adapts to the topic of community resilience, the Institutional Development Framework (Ostrom, Gardner, and Walker, 1994). • An Operational Framework (i.e., a three-phased application approach) – by means of which the model is applied in a specific context. The Operational framework builds on, and adapts to the topic of community resilience, the methodology proposed by the Council of Europe's Toolkit for Civil Participation in Decision-making processes (ISIG/CoE, 2017;2020). More specifically, the Operational Framework covers: - **Assessment** – Analysis of the components of local Resilience Ecosystem in terms of Overall context features (i.e., community assessment focused on context variables fostering or hindering resilience at local level, such as citizens' awareness, social bindings, etc.). Relevant stakeholders of the Resilience Ecosystem (so to identify potential members of Citizens-Scientists Networks). - **Contextualisation** – Setting up of Citizens-Scientists Networks (CSN), participatory research-action mechanisms/platforms composed by identified stakeholders. - **Implementation** – Development of context-based Stakeholders' Engagement Strategy (SES) and Action Plans tailored to the specific needs of every local context, to make CSN work effectively.

Copyright © FirEUrisk Consortium. All rights reserved.

As a direct result of the implementation of the engagement activities developed within FirEUrisk project applying the above-described framework, three community profiles have been identified, each representing a distinct level of participation in wildfire risk reduction:

- Informative Engagement Communities: these communities have limited experience with participatory processes and require awareness-raising initiatives. Suggested activities include public meetings, brochures, social media campaigns, and accessible educational materials.
- Consultative Engagement Communities: these communities are open to dialogue but lack well-structured participatory mechanisms. Engagement strategies should focus on structured consultations, stakeholder panels, and town hall meetings to gather input and foster dialogue.
- Collaborative Engagement Communities: these communities demonstrate a high level of engagement and willingness to co-create risk reduction strategies. The best approach involves forming citizen-led committees, community monitoring groups, and implementing co-designed fire prevention projects.

The diagram below illustrates the main operational phases of the model and outlines main suggestions/recommendations for the three community profiles, as extrapolated from the filed/pilot implementation of the FirEUrisk participatory model within the project activities.



Operational phases of the model and community profiles

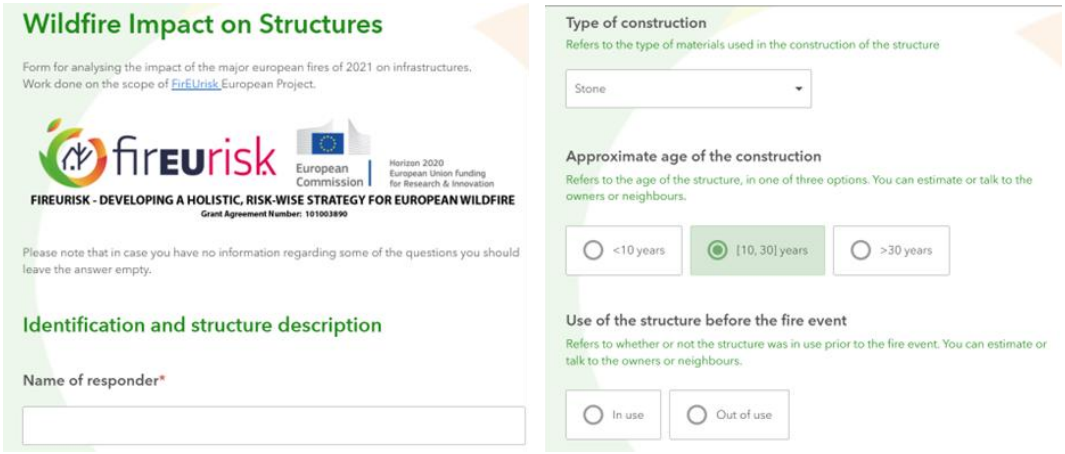
Contact

Riccardo Laterza, ISIG: laterza@isig.it

Ramona Velea, ISIG: velea@isig.it

Copyright © FirEUrisk Consortium. All rights reserved.

5.7.3. Guidelines for on-site surveys and subsequent data processing

Description	Protocol guiding the procedures to be followed during the on-site analysis of wildfires during the fire event and aftermath. The guidelines oriented to carry out tasks efficiently, safely and according to legal requirements. Relevant equipment and materials for the study are also suggested, as well as software that facilitates the treatment and exploitation of the collected data.
Type & format	Document (.pdf)
Update Frequency	5 years
Methodology	This product will have the following components: • Guidelines to get relevant data, efficiently and safely, during a fire event and aftermath – will be descriptive and will be based on the existing literature and the expertise of the consortium. • User friendly forms to be used in gadgets to get in the field
Contact	Domingos Xavier Viegas, ADAI: xavier.viegas@dem.uc.pt
Overview	 *Representative screenshots of FirEUrisk app to characterize the impacts on infrastructures*

Copyright © FirEUrisk Consortium. All rights reserved.

6. Open Access Tools and other integration resources

6.1. FirEUrisk Open Platform

The **FirEUrisk Open Platform** serves as a critical resource for wildfire risk management in Europe, offering robust data integration, advanced visualization capabilities, and a collaborative knowledge-sharing environment. Its ongoing development will continue to enhance stakeholders' ability to understand, anticipate, and mitigate the impacts of wildfires, ultimately contributing to a more resilient and safer Europe. The effective integration and dissemination of wildfire risk information across Europe, both among internal partners and external stakeholders, including end-users and the general public, is crucial for the success of the FirEUrisk project.

The platform serves as a **one-stop shop** for wildfire risk data, models, and knowledge in Europe. **Facilitates communication and integration** among online services within the project. **Maximizes dissemination** of content and recommendations for risk-based fire management. **Provides free access** to datasets, tools, and training materials developed during the project. **Serves a wide range of stakeholders**, including fire services, forest services, civil protection agencies, planners, and policy makers.

The Open platform is designed to consist of three distinct online services developed in the context of FirEUrisk, as illustrated in the following figure (Figure 15).

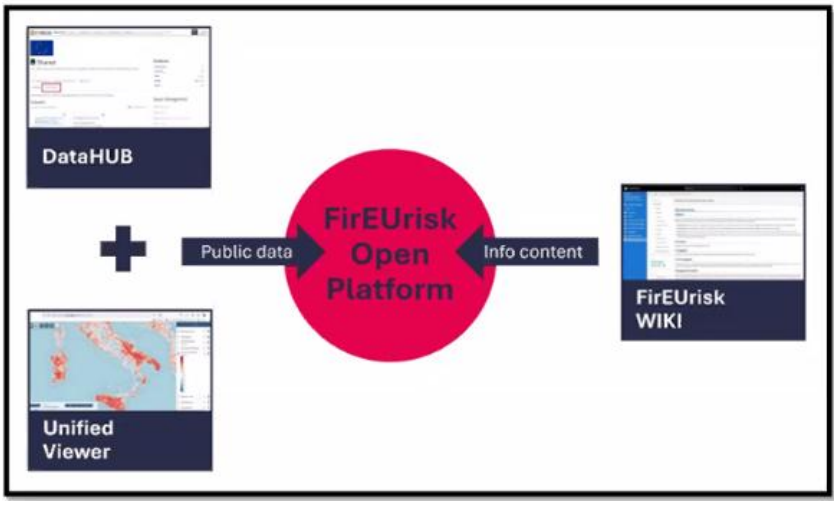


Figure 15. FirEUrisk Open Platform schema.

These services include:

- **FirEUrisk DataHUB** (https://fireurisk.satways.net): **The internal data repository service, which enables the storage and management of scientific information and datasets**. Data Repository enables the sharing, organization and analysis of large datasets, models and knowledge. Using their preferred browser, users can log in and be informed about the datasets that have been uploaded by other users or manage their list of datasets. Additionally, a fully functional API is provided, enabling the execution of the framework functionalities and the usage of the information that has been uploaded to it, through any external tool. The DataHUB Data Repository is based on the Clowder open-source framework (Figure 16).

Copyright © FirEUrisk Consortium. All rights reserved.

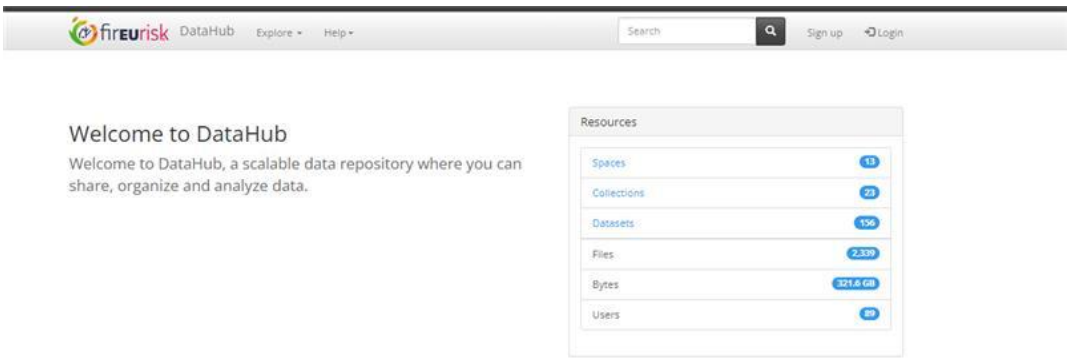


Figure 16. FirEUrisk DataHUB Data Repository main page

- **FirEUrisk Viewer** (https://proms.arbonaut.com/newproms): **A GIS-based service that facilitates the visualization of the geospatial data sourced from DataHUB and other existing external platforms across Europe**. Tool for displaying outputs from the internal platform and external platforms customised for the FirEUrisk needs. 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 (Figure 17).

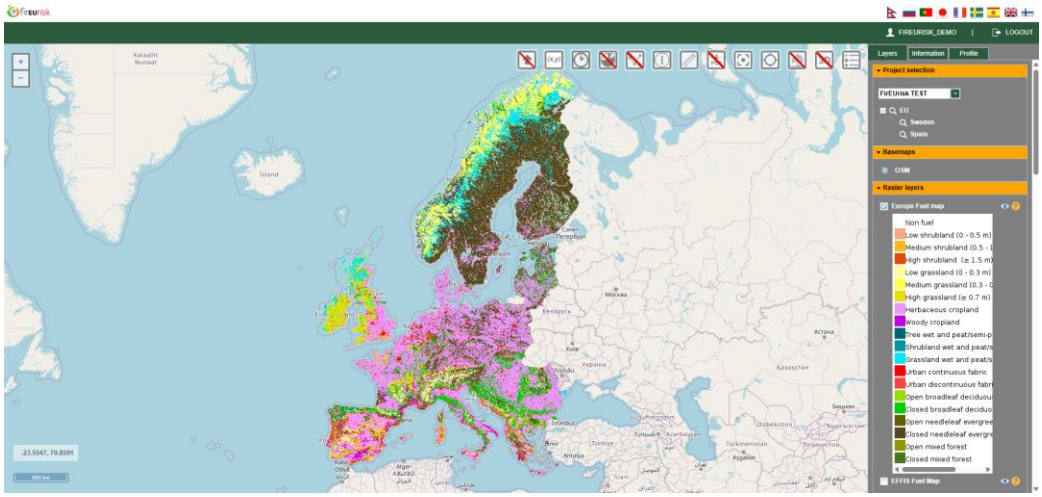


Figure 17. FirEUrisk Viewer

- **FirEUrisk WIKI** (https://fireurisk.wiki.satways.cloud/en/public): **A collaborative wiki service for the exchange of information and knowledge**. Tool service was developed to enhance knowledge sharing and foster collaboration. It serves as a centralized repository for information and documentation on data, models and tools produced and/or used during the project: (1) ensuring transparency, (2) encouraging community engagement, and (3) providing a dynamic space for contributors to share insights, updates and resources. The WIKI aligns with the FirEUrisk's commitment to openness and knowledge dissemination, supporting the wider community in understanding and contributing to the goals of project (Figure 18).

Copyright © FirEUrisk Consortium. All rights reserved.

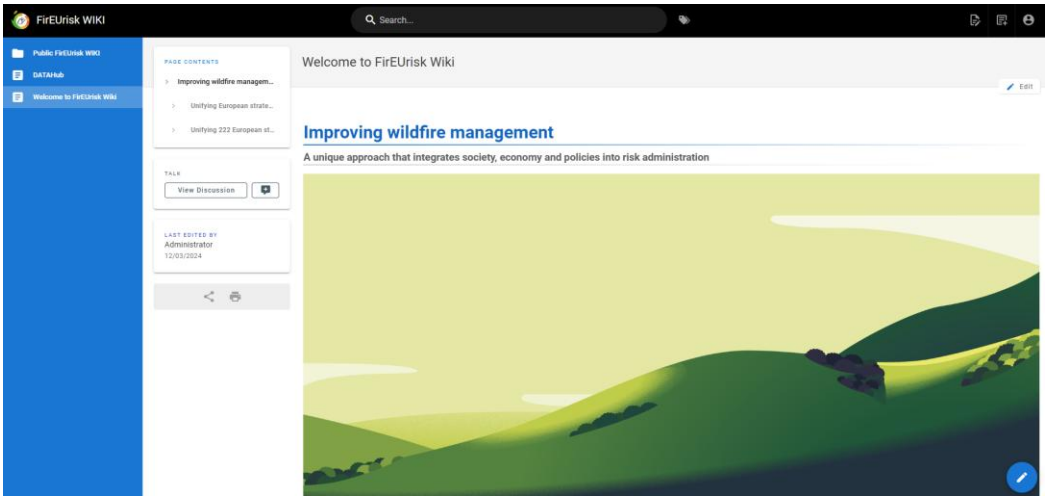


Figure 18. FirEUrisk WIKI main page

These services collectively constitute the platform's structural components, facilitating seamless integration and functionality. DataHUB currently hosts an extensive collection of data and corresponding metadata, providing open access to external users. DataHUB also features a robust mapping capability utilizing GeoServer to create visual displays of geospatial data on a base map. The Unified Viewer employs these Web Map Service (WMS) outputs to showcase and manage both static and dynamic geospatial data that is publicly available via DataHUB, along with data from specific external sources. Additionally, as part of the Open Platform, the FirEUrisk WIKI serves as a comprehensive knowledge base for wildfire risk assessment, adaptation, and mitigation strategies. This interactive wiki service allows users to engage with and expand upon its content by contributing their own insights.

6.2. Other integration resources

6.2.1. FirEUrisk Mobile App

In line with the importance of fostering public participation in the design and implementation of fire risk assessment methodologies, an Android-based mobile application, 'FirEUrisk,' has been developed (Figure 19). The primary purpose of this mobile application is to **disseminate information from the project to citizens residing in fire-prone areas and to solicit their involvement in reducing fire risk**. This mobile app enables citizens to report real-time forest fire alerts, ground fuel information, and any fire-related damages. Additionally, it offers essential features such as satellite-based fire alerts (MODIS and VIIRS) and FirEUrisk project outputs, including fuel type maps and fire weather indices.

The **FirEUrisk Mobile App** (https://play.google.com/store/apps/details?id=com.uah.fireurisk&hl=en&pli=1) consists of three basic buttons: fire risk, fire alerts, and post-fire impacts. Citizens must register with the mobile app to report data on ground fuels, fire alerts, and fire effects. The app displays near real-time active fire alerts from MODIS and VIIRS (MODIS NRT, MODIS SNPP NRT, and VIIRS NOAA 20 NRT), as well as regular products such as MODIS SP and VIIRS SNPP SP. This data is retrieved from the NASA Fire Information for Resource Management System (FIRMS). Furthermore, the mobile app can display FirEUrisk project outputs such as fuel type maps, Fire Weather Index, weather parameters, and fire propagation models once they are made accessible by the responsible organization.

Copyright © FirEUrisk Consortium. All rights reserved.

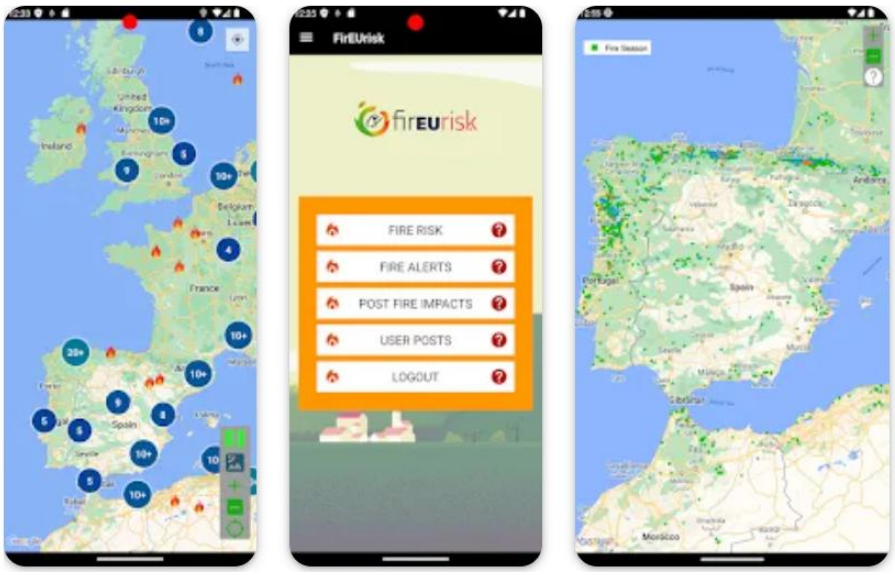


Figure 19. FirEUrisk Mobile App.

6.2.2. FirEUrisk website

The following describes the resources and outputs available on the project's website, which aim to enhance and disseminate wildfire risk assessment, management, and mitigation strategies across Europe.

- **Scientific Publications** (https://fireurisk.eu/scientific-publications/): The FirEUrisk project provides a comprehensive repository of scientific publications that cover various aspects of wildfire risk. Key topics include: Ecological values, Ecosystems, Exposure, Fire danger, Fire policies, Fire reduction, Fire risk assessment, Fuels, Population & assets, Propagation, and Weather.
- **Deliverables** (https://fireurisk.eu/deliverables/): FirEUrisk's deliverables include technical and detailed reports and documents that outcomes the project's methodologies, findings, and recommendations.
- **Training Event Materials** (https://fireurisk.eu/training-event-materials/): FirEUrisk offers materials from various training events aimed at enhancing wildfire management skills. These are divided into three key training topics:
  1. The FirEUrisk fuel classification system and the European fuel map [UAH]: the training provides an overview of the project's new fuel classification system, providing attendees with the knowledge and tools necessary to use it and explore the related European fuel map to assess fire risk in Europe.
  2. Mapping the Wildland Urban Interface (WUI) [HU]: this training provides an overview of the current state-of-the-art in WUI mapping, providing attendees with the knowledge to choose the best strategy to create WUI maps for their region of interest.
  3. Guidelines and tools for extreme fire and fire in WUI management [ADAI, SAFE Cluster, Meteogrid & UAVR]: Past events and research have highlighted weaknesses in responders' ability to face extreme fires and fires occurring in the WUI areas. Furthermore, scientific projections suggest that the frequency of such fires is likely to increase in the future, making it essential for responders to be equipped with a solid understanding of extreme fire behavior and the specific challenges posed by WUI environments. This workshop is designed for civil protection, environmental, and health professionals, focusing on the rapidly evolving challenges in Europe.

Copyright © FirEUrisk Consortium. All rights reserved.

It aims to bridge the gap between research and operational practices by sharing the knowledge and tools developed through the FirEURisk project. Participants will gain valuable insights and practical guidance to improve their preparedness and response capabilities in facing the new challenges of extreme fires and fire in WUIs.

4. Understanding climate scenarios and data for wildfire studies: Key concepts and best practices [Meteogrid]: This training provided participants with a comprehensive understanding of climate scenarios, key terminology, and best practices for using climate data in wildfire studies. It covered the differences between climate models and scenarios and their implications for fire risk assessment. Participants also explored methods for integrating climate projections into wildfire research and adaptation planning, equipping them with the knowledge to make informed decisions in fire-prone landscapes. Additionally, the training offered practical guidance on accessing and downloading climate data, introducing key software tools for data manipulation, such as CDO. A hands-on tutorial with dummy data and scripts was provided, allowing participants to practice data processing and analysis independently.

- **Webinars** (https://fireurisk.eu/webinars/): The project hosts webinars that provide insights into wildfire risk management strategies and research findings. These webinars offer a platform for sharing knowledge and best practices among experts and stakeholders. Webinars sessions are:
  - FirEURisk Information, Data and Visualisation Tools. Mar. 2025.
  - Managing & living with wildfires in Europe: Highlights on Integrated Wildfire Risk Management from FirEURisk & SILVANUS EU Horizon projects. Feb. 2025.
  - Integrated wildfire risk management strategy (IWRM) for Europe. Jan. 2025.
  - Wildfire Risk Management in Croatia. Feb. 2024.
  - Preliminary outcomes on wildfire risk management, citizen engagement and policy review in Europe. Apr. 2023.
  - Perspectives on landscape management to reduce wildfire risk. Mar. 2023.
  - Spanish strategy of fire risk assessment, reduction and adaptation. Feb. 2023.
  - Major fire events of 2021 in the Mediterranean Basin. Dec. 2021.
  - Future fire scenarios and biodiversity. Sep. 2021.
- **Technical reports and policy briefs** (https://fireurisk.eu/reports/): The project provides detailed reports on critical wildfire events and policy briefs. Key reports include analyses of 2021 wildfire events in the Mediterranean region, large wildfires of 2022 in Europe, and policy briefs on fire risk management. These reports offer valuable data and recommendations for policymakers and practitioners working to mitigate wildfire risks.

6.3. Future implementations within existing fire risk platforms

The roadmap outlines the implementation of prototype datasets and services within existing systems and details the future integration of FirEURisk prototype products with established fire risk platforms such as EFFIS, DRMKC, and Copernicus. Currently, active communication is ongoing with EFFIS, which has expressed interest in incorporating some of the products developed by FirEURisk into their system. These products include static items (e.g., fuel maps, vulnerability maps) as well as the methods and algorithms for dynamic items (e.g., fuel moisture contents).
Additionally, a unified tool interface has been developed to display outputs from both the internal platform and existing platforms. This interface utilizes the WMS API provided by the FirEURisk Public Cooperative Platform, demonstrating

Copyright © FirEURisk Consortium. All rights reserved.

interoperability at the user interface level. The selected products are seamlessly integrated into the unified user interface, enabling the overlay of EFFIS and FirEUrisk map products.

Copyright © FirEUrisk Consortium. All rights reserved.

7. Conclusions and position statements

The number of tangible results evidence the step ahead fostered by FirEURisk project in preventing wildfire risk.

This section attempts at noting some straightforward conclusions in relation to the objectives traced in the work plan. The following are the key takeaway messages that the FirEurisk team would like to spread boldly across the board, from EU institutions to the first responders or the public at large.

- As a **multifactor hazard,** wildfire risk requires an array of actors and resources effectively managed: technical, socio-economic, legal and political solutions operating for the same purpose: prevent life and nature destruction.
- FirEURisk has attained and demonstrated a **schema to integrate** all wildfire phases: prevention, monitoring, preparedness, response, and restoration. The key components to **assess** wildfire **risk** are danger, exposure and vulnerability. The wildfire risk assessment component further implements risk **mitigation/reduction** and risk **adaptation**.
- The integration schema operates consistently at different spatial and temporal **scales**, i.e.: local, regional and continental, making the most of **available data,** while keeping the methodological coherence. Likewise, instrumental factors like legal frameworks, economic analysis, guidelines, non-fire hazards, display platforms, etc… are key and can be easily incorporated to the overall wildfire risk assessment, reduction and adaptation.
- The general integration scheme has identified a **line of action** for the near future consisting in enlarging the model to integrate fire risks with other non-fire hazards.
- FirEurisk has implemented **62 solutions** across the components of the integration scheme, **updating** methods of fire risk assessment, including socio-economic and ecological impacts of wildfires, considering the value of properties, natural capital, ecosystem and ecological services. New models and indexes have been published.
    - Solutions are offered under **three portfolios** of products: geospatial, training, methodological and analytical. Portfolios include products to handle wildfire risk assessment (danger, exposure, vulnerability), mitigation and reduction, adaptation, and integration (conceptual and instrumental).
    - The European portfolio offers 20 products standardised at 1 km^2 for the whole continent.
    - The regional portfolio offers 23 products standardised at 1 ha. for the regional pilot sites.
    - The local portfolio offers 19 products at various scales and locations
- Fifty-five (**55**) products have been **showcased and validated** during *ad-hoc* demonstration events, enlarging the network of stakeholders in 983 attendants.
- **Best valued** products by stakeholders during the demonstration events include (non-exhaustive):
    - Wildland-Urban Interface map
    - Spring grassland fire model
    - Fuel Models
    - Fuel type, fuel model, canopy metrics, and landscape file
    - Forest fire emission forecast
    - **Wildfire** spread and behavior, FlamMap
    - Fuel Management Framework for Reducing Operation-based Ignitions
    - Forest condition biotic damages map

Copyright © FirEURisk Consortium. All rights reserved.

    - Future fire regimes database
- The **technical readiness level** attained by products identifies **two areas of action** in the near future:
    - 39 products (TRL ≥ 4) can boost, evolving to a **prototype** stage, thus the whole system could qualify (TRL-8) and be proven in an operational environment (TRL-9).
    - 23 products (TRL 2-3) can evolve to **technology validated** and demonstrated.
- **Open access tools are key** to an integrated wildfire risk management (IWRM) system. Universal open access to data sets, models and final products is the means for spanning a standard system across stakeholders and regions.
- FirEUrisk offers an **integrated wildfire risk management (IWRM) framework** for Europe**,** with an **action plan,** a **roadmap** and the recommendation for an Interagency dedicated to the IWRM in the EU.

Annex B provides a table illustrating the FirEUrisk Product Portfolio cross-referencing integration across European, regional, and local scales within the IWRM framework, mapping components from danger assessment through risk adaptation to instrumental (integration) products.

Copyright © FirEUrisk Consortium. All rights reserved.

8. References

[1] E. Chuvieco *et al.*, "Towards an integrated approach to wildfire risk assessment: when, where, what and how may the landscapes burn," *Fire*, vol. 6, no. 5, p. 215, 2023.

[2] C. Ochoa, A. Bar-Massada, and E. Chuvieco, "A European-scale analysis reveals the complex roles of anthropogenic and climatic factors in driving the initiation of large wildfires," *Science of The Total Environment*, vol. 917, p. 170443, 2024, doi: https://doi.org/10.1016/j.scitotenv.2024.170443.

[3] V. Pampanoni *et al.*, "Early Validation of A Live Fuel Moisture Content Product Based on Sentinel-2 and Sentinel-3 Images," in *IGARSS 2023 - 2023 IEEE International Geoscience and Remote Sensing Symposium*, 2023, pp. 3042–3045. doi: 10.1109/IGARSS52108.2023.10281970.

[4] V. Pampanoni, G. Laneve, S. Saquella, and A. Ferrari, "Using Prosail Look-Up Tables to Train Random Forests Regressors for Fast Live Fuel Moisture Retrieval," in *IGARSS 2024 - 2024 IEEE International Geoscience and Remote Sensing Symposium*, 2024, pp. 4526–4530. doi: 10.1109/IGARSS53475.2024.10642386.

[5] E. Aragoneses, M. García, M. Salis, L. M. Ribeiro, and E. Chuvieco, "Classification and mapping of European fuels using a hierarchical, multipurpose fuel classification system," *Earth Syst. Sci. Data*, vol. 15, no. 3, pp. 1287–1315, Mar. 2023, doi: 10.5194/essd-15-1287-2023.

[6] E. Aragoneses, M. García, P. Ruiz-Benito, and E. Chuvieco, "Mapping forest canopy fuel parameters at European scale using spaceborne LiDAR and satellite data," *Remote Sens Environ*, vol. 303, p. 114005, 2024, doi: https://doi.org/10.1016/j.rse.2024.114005.

[7] E. Aragoneses, M. García, H. Tang, and E. Chuvieco, "A multi-sensor approach allows confident mapping of forest canopy fuel load and canopy bulk density to assess wildfire risk at the European scale," *Remote Sens Environ*, vol. 318, p. 114578, 2025, doi: https://doi.org/10.1016/j.rse.2024.114578.

[8] D. Zanaga *et al.*, "ESA WorldCover 10 m 2021 v200." [Online]. Available: https://zenodo.org/records/7254221

[9] V. C. Radeloff, R. B. Hammer, S. I. Stewart, J. S. Fried, S. S. Holcomb, and J. F. McKeefry, "THE WILDLAND–URBAN INTERFACE IN THE UNITED STATES," *Ecological Applications*, vol. 15, no. 3, pp. 799–805, Jun. 2005, doi: https://doi.org/10.1890/04-1413.

[10] A. Bar-Massada, S. I. Stewart, R. B. Hammer, M. H. Mockrin, and V. C. Radeloff, "Using structure locations as a basis for mapping the wildland urban interface," *J Environ Manage*, vol. 128, pp. 540–547, 2013, doi: https://doi.org/10.1016/j.jenvman.2013.06.021.

[11] A. R. Carlson, D. P. Helmers, T. J. Hawbaker, M. H. Mockrin, and V. C. Radeloff, "The wildland–urban interface in the United States based on 125 million building locations," *Ecological Applications*, vol. 32, no. 5, p. e2597, Jul. 2022, doi: https://doi.org/10.1002/eap.2597.

[12] M. E. Castillo, J. R. Molina, F. Rodríguez y Silva, P. García-Chevesich, and R. Garfias, "A system to evaluate fire impacts from simulated fire behavior in Mediterranean areas of Central Chile," *Science of The Total Environment*, vol. 579, pp. 1410–1418, 2017, doi: https://doi.org/10.1016/j.scitotenv.2016.11.139.

[13] M. V. Román, D. Azqueta, and M. Rodrígues, "Methodological approach to assess the socio-economic vulnerability to wildfires in Spain," *For Ecol Manage*, vol. 294, pp. 158–165, 2013, doi: https://doi.org/10.1016/j.foreco.2012.07.001.

Copyright © FirEURisk Consortium. All rights reserved.

[14] J. R. Molina Martínez, M. Herrera Machuca, R. Zamora Díaz, F. Rodríguez y Silva, and A. González-Cabán, "Economic losses to Iberian swine production from forest fires," *For Policy Econ*, vol. 13, no. 8, pp. 614–621, 2011, doi: https://doi.org/10.1016/j.forpol.2011.07.011.

[15] J. R. Molina, M. A. Herrera, and F. Rodríguez y Silva, "Wildfire-induced reduction in the carbon storage of Mediterranean ecosystems: An application to brush and forest fires impacts assessment," *Environ Impact Assess Rev*, vol. 76, pp. 88–97, 2019, doi: https://doi.org/10.1016/j.eiar.2019.02.008.

[16] E. Gomez and K. Alvarez, *Forest fires: Detection, suppression and prevention*. Nova Science Publishers, 2009.

[17] European Commission *et al.*, *Ecosystem services accounting . Part I, Outdoor recreation and crop pollination*. Publications Office of the European Union, 2018. doi: doi/10.2760/619793.

[18] European Commission *et al.*, *Ecosystem services accounting . Part III, Pilot accounts for habitat and species maintenance, on-site soil retention and water purification*. Publications Office of the European Union, 2021. doi: doi/10.2760/636621.

[19] M. Kummu, M. Taka, and J. H. A. Guillaume, "Gridded global datasets for Gross Domestic Product and Human Development Index over 1990–2015," *Sci Data*, vol. 5, no. 1, p. 180004, 2018, doi: 10.1038/sdata.2018.4.

[20] F. Milazzo, P. Fernández, A. Peña, and T. Vanwalleghem, "The resilience of soil erosion rates under historical land use change in agroecosystems of Southern Spain," *Science of The Total Environment*, vol. 822, p. 153672, 2022, doi: https://doi.org/10.1016/j.scitotenv.2022.153672.

[21] E. Dinerstein *et al.*, "A conservation assessment of the terrestrial ecorregions of Latin America and the Caribbean," Banco Mundial, Washington DC, Sep. 1995. Accessed: Feb. 13, 2025. [Online]. Available: http://documents.worldbank.org/curated/en/957541468270313045

[22] P. Brun *et al.*, "The productivity-biodiversity relationship varies across diversity dimensions," *Nat Commun*, vol. 10, no. 1, p. 5691, 2019, doi: 10.1038/s41467-019-13678-1.

[23] M. S. Sritharan, B. C. Scheele, W. Blanchard, C. N. Foster, P. A. Werner, and D. B. Lindenmayer, "Plant rarity in fire-prone dry sclerophyll communities," *Sci Rep*, vol. 12, no. 1, p. 12055, 2022, doi: 10.1038/s41598-022-15927-8.

[24] T. Andersen, J. Carstensen, E. Hernández-García, and C. M. Duarte, "Ecological thresholds and regime shifts: approaches to identification," *Trends Ecol Evol*, vol. 24, no. 1, pp. 49–57, 2009, doi: https://doi.org/10.1016/j.tree.2008.07.014.

[25] F. Arrogante-Funes, F. Mouillot, B. Moreira, I. Aguado, and E. Chuvieco, "Mapping and assessment of ecological vulnerability to wildfires in Europe," *Fire Ecology*, vol. 20, no. 1, p. 98, 2024, doi: 10.1186/s42408-024-00321-8.

[26] J. T. Stevens, M. M. Kling, D. W. Schwilk, J. M. Varner, and J. M. Kane, "Biogeography of fire regimes in western US conifer forests: A trait-based approach," *Global Ecology and Biogeography*, vol. 29, no. 5, pp. 944–955, 2020.

[27] S. Archibald, G. P. Hempson, and C. Lehmann, "A unified framework for plant life-history strategies shaped by fire and herbivory," *New Phytologist*, vol. 224, no. 4, pp. 1490–1503, Dec. 2019, doi: https://doi.org/10.1111/nph.15986.

[28] P. Vargas, R. Heleno, and J. M. Costa, "EuDiS - A comprehensive database of the seed dispersal syndromes of the European flora," *Biodivers Data J*, vol. 11, p. e104079, Jul. 2023, [Online]. Available: https://doi.org/10.3897/BDJ.11.e104079

Copyright © FirEURisk Consortium. All rights reserved.

[29] C. Schwörer, P. D. Henne, and W. Tinner, "A model-data comparison of Holocene timberline changes in the Swiss Alps reveals past and future drivers of mountain forest dynamics," *Glob Chang Biol*, vol. 20, no. 5, pp. 1512–1526, May 2014, doi: https://doi.org/10.1111/gcb.12456.

[30] A. N. Neidermeier, C. Zagaria, V. Pampanoni, T. A. P. West, and P. H. Verburg, "Mapping opportunities for the use of land management strategies to address fire risk in Europe," *J Environ Manage*, vol. 346, p. 118941, 2023, doi: https://doi.org/10.1016/j.jenvman.2023.118941.

[31] A. N. Neidermeier, C. Zagaria, V. Pampanoni, T. A. P. West, and P. H. Verburg, "Mapping opportunities for the use of land management strategies to address fire risk in Europe," *J Environ Manage*, vol. 346, p. 118941, 2023, doi: https://doi.org/10.1016/j.jenvman.2023.118941.

[32] A. Neidermeier, "Data for Mapping opportunities for the use of land management strategies to address fire risk in Europe (FirEUrisk) [Dataset]," 2023, *DataverseNL*. doi: https://doi.org/10.34894/JQS5MD.

[33] R. C. Rothermel, *A mathematical model for predicting fire spread in wildland fuels*, vol. 115. Intermountain Forest & Range Experiment Station, Forest Service, US …, 1972.

[34] R. C. Rothermel, *How to predict the spread and intensity of forest and range fires*, vol. 143. US Department of Agriculture, Forest Service, Intermountain Forest and Range …, 1983.

[35] D. X. F. C. Viegas, J. R. N. Raposo, C. F. M. Ribeiro, L. C. D. Reis, A. Abouali, and C. X. P. Viegas, "On the non-monotonic behaviour of fire spread," *Int J Wildland Fire*, vol. 30, no. 9, pp. 702–719, 2021, doi: https://doi.org/10.1071/WF21016.

[36] D. X. F. C. Viegas *et al.*, "On the intermittent nature of forest fire spread – Part 2," *Int J Wildland Fire*, vol. 31, no. 10, pp. 967–981, 2022, doi: https://doi.org/10.1071/WF21098.

[37] K. Winkler, R. Fuchs, M. Rounsevell, and M. Herold, "Global land use changes are four times greater than previously estimated," *Nat Commun*, vol. 12, no. 1, p. 2501, 2021, doi: 10.1038/s41467-021-22702-2.

[38] A. Neidermeier, "Continental Land Use Change scenarios and stylized fuel management scenarios (FirEUrisk) [Dataset]," 2022, *DataverseNL*. doi: 10.5281/zenodo.12533018.

[39] A. Jiménez-Ruano *et al.*, "Assessing human-caused wildfire ignition likelihood across Europe," in *2023 8th International Conference on Smart and Sustainable Technologies (SpliTech)*, IEEE, Jun. 2023, pp. 1–6. doi: 10.23919/SpliTech58164.2023.10193249.

[40] P. J. Gelabert *et al.*, "Assessing human-caused wildfire ignition likelihood across Europe," *EGUsphere*, vol. 2025, pp. 1–27, Jan. 2025, doi: 10.5194/egusphere-2025-143.

[41] M. Yebra, X. Quan, D. Riaño, P. Rozas Larraondo, A. I. J. M. van Dijk, and G. J. Cary, "A fuel moisture content and flammability monitoring methodology for continental Australia based on optical remote sensing," *Remote Sens Environ*, vol. 212, pp. 260–272, 2018, doi: https://doi.org/10.1016/j.rse.2018.04.053.

[42] M. Forkel, L. Schmidt, R.-M. Zotta, W. Dorigo, and M. Yebra, "Estimating leaf moisture content at global scale from passive microwave satellite observations of vegetation optical depth," *Hydrol. Earth Syst. Sci.*, vol. 27, no. 1, pp. 39–68, Jan. 2023, doi: 10.5194/hess-27-39-2023.

[43] R. E. Keane, "Describing wildland surface fuel loading for fire management: a review of approaches, methods and systems," *Int J Wildland Fire*, vol. 22, no. 1, pp. 51–62, 2013, [Online]. Available: https://doi.org/10.1071/WF11139

[44] P. L. Andrews, C. D. Bevins, and R. C. Seli, "BehavePlus fire modeling system, version 4.0: User's Guide," U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, 2005. doi: 10.2737/rmrs-gtr-106.

Copyright © FirEUrisk Consortium. All rights reserved.

[45] M. A. Finney, "FARSITE: Fire Area Simulator-model development and evaluation," U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, 1998. doi: 10.2737/rmrs-rp-4.

[46] V. Bacciu *et al.*, "Mediterranean maquis fuel model development and mapping to support fire modeling," in *EGU General Assembly Conference Abstracts*, Apr. 2009, p. 13148. [Online]. Available: https://ui.adsabs.harvard.edu/abs/2009EGUGA..1113148B

[47] P. Duce *et al.*, "Fuel types and potential fire behavior in Sardinia and Corsica islands: a pilot study, in: Spano, D., Bacciu, V., Salis, M., Sirca, C. (Eds.), Modelling Fire Behaviour and Risk," *Nuova StampaColor*, p. 208, 2012.

[48] J. K. Brown, R. D. Oberheu, and C. M. Johnston, "Handbook for inventorying surface fuels and biomass in the Interior West," U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, 1982. doi: 10.2737/int-gtr-129.

[49] N. Goatin, "Modelli di combustibile nei boschi termofili della Lessinia (VR) per la predizione del comportamento del fronte di fiamma," 2011.

[50] C. Zanella, "Caratterizzazione dei combustibili vegetali e applicazione del software Flammap per la previsione del comportamento degli incendi boschivi," 2016.

[51] G. Pellizzaro, V. Bacciu, D. Spano, and P. Duce, "I sistemi di classificazione del combustibile, in: Bacciu, V., Salis, M., Spano, D. (Eds.), Strumenti e modelli a supporto della pianificazione, prevenzione e difesa dagli incendi boschivi," *Nuova StampaColor*, pp. 21–49, 2015.

[52] R. E. Keane, "Wildland fuel fundamentals and applications," Springer, 2015.

[53] V. Resco de Dios *et al.*, "Convergence in critical fuel moisture and fire weather thresholds associated with fire activity in the pyroregions of Mediterranean Europe," *Science of The Total Environment*, vol. 806, p. 151462, 2022, doi: https://doi.org/10.1016/j.scitotenv.2021.151462.

[54] M. Rodrigues, V. Resco de Dios, Â. Sil, À. Cunill Camprubí, and P. M. Fernandes, "VPD-based models of dead fine fuel moisture provide best estimates in a global dataset," *Agric For Meteorol*, vol. 346, p. 109868, 2024, doi: https://doi.org/10.1016/j.agrformet.2023.109868.

[55] A. Bar-Massada, F. Alcasena, F. Schug, and V. C. Radeloff, "The wildland – urban interface in Europe: Spatial patterns and associations with socioeconomic and demographic variables," *Landsc Urban Plan*, vol. 235, p. 104759, 2023, doi: https://doi.org/10.1016/j.landurbplan.2023.104759.

[56] T. Osswald, C. Gama, A. P. Fernandes, D. Lopes, V. Varela, and A. I. Miranda, "Effects of the wildfires in August 2021 on the air quality of Athens through a numerical simulation," *Int J Wildland Fire*, vol. 32, no. 11, pp. 1633–1645, 2023, [Online]. Available: https://doi.org/10.1071/WF22148

[57] M. Sánchez-Pinillos, L. Coll, M. De Cáceres, and A. Ameztegui, "Assessing the persistence capacity of communities facing natural disturbances on the basis of species response traits," *Ecol Indic*, vol. 66, pp. 76–85, 2016, doi: https://doi.org/10.1016/j.ecolind.2016.01.024.

[58] M. Billing *et al.*, "Projections of future fire and vegetation variables on European scale," 2023. doi: https://doi.org/10.5880/pik.2023.005.

[59] A. Fernandez-Carrillo, Z. Patočka, L. Dobrovolný, A. Franco-Nieto, and B. Revilla-Romero, "Monitoring bark beetle forest damage in central europe. A remote sensing approach validated with field data," *Remote Sens (Basel)*, vol. 12, no. 21, pp. 1–19, 2020, doi: 10.3390/rs12213634.

[60] E. Commission *et al.*, "Monitoring of forests through remote sensing: final report," Publications Office, 2020. doi: doi/10.2779/175242.

Copyright © FirEUrisk Consortium. All rights reserved.

[61] A. Turbé *et al.*, "Disturbances of EU forests caused by biotic agents: final report," 2012.

[62] A. Fernandez-Carrillo, A. Franco-Nieto, M. J. Yagüe-Ballester, and M. Gómez-Giménez, "Predictive Model for Bark Beetle Outbreaks in European Forests," *Forests*, vol. 15, Jun. 2024, doi: 10.3390/f15071114.

[63] A. Fernandez-Carrillo, A. Franco-Nieto, M. J. Yagüe Ballester, and M. Gómez-Giménez, "Bark beetle predictive model results (FirEUrisk) [Dataset]," Jun. 25, 2024, *Zenodo*. doi: 10.5281/zenodo.12533018.

[64] G. Laneve, V. Pampanoni, and R. Uddien Shaik, "The Daily Fire Hazard Index: A Fire Danger Rating Method for Mediterranean Areas," *Remote Sens (Basel)*, vol. 12, no. 15, 2020, doi: 10.3390/rs12152356.

[65] R. Malinowski *et al.*, "Automated Production of a Land Cover/Use Map of Europe Based on Sentinel-2 Imagery," *Remote Sens (Basel)*, vol. 12, no. 21, 2020, doi: 10.3390/rs12213523.

[66] H.-E. Andersen, R. J. McGaughey, and S. E. Reutebuch, "Estimating forest canopy fuel parameters using LIDAR data," *Remote Sens Environ*, vol. 94, no. 4, pp. 441–449, 2005, doi: https://doi.org/10.1016/j.rse.2004.10.013.

[67] J. Sjöström and A. Granström, "A phenology-driven fire danger index for northern grasslands," *Int J Wildland Fire*, vol. 32, no. 9, pp. 1332–1346, 2023, [Online]. Available: https://doi.org/10.1071/WF23013

[68] M. A. Finney, "A computational method for optimising fuel treatment locations," *Int J Wildland Fire*, vol. 16, no. 6, 2007, doi: 10.1071/WF06063.

[69] V. Myroniuk, M. Kutia, A. J. Sarkissian, A. Bilous, and S. Liu, "Regional-Scale Forest Mapping over Fragmented Landscapes Using Global Forest Products and Landsat Time Series Classification," *Remote Sens (Basel)*, vol. 12, no. 1, 2020, doi: 10.3390/rs12010187.

[70] J. H. Scott and R. E. Burgan, "Standard fire behavior fuel models: a comprehensive set for use with Rothermel's surface fire spread model," U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, 2005. doi: 10.2737/rmrs-gtr-153.

[71] M. C. Hansen *et al.*, "High-resolution global maps of 21st-century forest cover change," *Science (1979)*, vol. 342, no. 6160, 2013, doi: 10.1126/science.1244693.

[72] M. Simard, N. Pinto, J. B. Fisher, and A. Baccini, "Mapping forest canopy height globally with spaceborne lidar," *J Geophys Res Biogeosci*, vol. 116, no. G4, Dec. 2011, doi: https://doi.org/10.1029/2011JG001708.

[73] L. Breiman, "Random Forests," *Mach Learn*, vol. 45, no. 1, pp. 5–32, 2001, doi: 10.1023/A:1010933404324.

[74] M. H. A. Baig, L. Zhang, T. Shuai, and Q. Tong, "Derivation of a tasselled cap transformation based on Landsat 8 at-satellite reflectance," *Remote Sensing Letters*, vol. 5, no. 5, 2014, doi: 10.1080/2150704X.2014.915434.

[75] N. Gorelick, M. Hancher, M. Dixon, S. Ilyushchenko, D. Thau, and R. Moore, "Google Earth Engine: Planetary-scale geospatial analysis for everyone," *Remote Sens Environ*, vol. 202, pp. 18–27, Dec. 2017, doi: 10.1016/J.RSE.2017.06.031.

[76] A. Parson, P. R. Robichaud, S. A. Lewis, C. Napper, and J. T. Clark, "Field guide for mapping post-fire soil burn severity," *Gen. Tech. Rep. RMRS-GTR-243. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 49 p.*, vol. 243, 2010.

[77] J. Neris *et al.*, "Designing tools to predict and mitigate impacts on water quality following the Australian 2019/2020 wildfires: Insights from Sydney's largest water supply catchment," *Integr Environ Assess Manag*, vol. 17, no. 6, pp. 1151–1161, Nov. 2021, doi: 10.1002/ieam.4406.

[78] C. Sánchez-García *et al.*, "Chemical characteristics of wildfire ash across the globe and their environmental and socio-economic implications," *Environ Int*, vol. 178, p. 108065, 2023, doi: https://doi.org/10.1016/j.envint.2023.108065.

Copyright © FirEUrisk Consortium. All rights reserved.

[79] M. Ortega, A. L. Sancho, and J. R. Molina, "Visual-SEVEIF: a tool for economic planning on wildfire decision-making," in *2023 8th International Conference on Smart and Sustainable Technologies (SpliTech)*, 2023, pp. 1–7. doi: 10.23919/SpliTech58164.2023.10193546.

[80] F. Rodríguez y Silva, C. D. O'Connor, M. P. Thompson, J. R. Molina Martínez, and D. E. Calkin, "Modelling suppression difficulty: current and future applications," *Int J Wildland Fire*, vol. 29, no. 8, p. 739, 2020, doi: 10.1071/wf19042.

[81] F. Vermina Plathner, J. Sjöström, and A. Granström, "Garden structure is critical for building survival in northern forest fires – An analysis using large Swedish wildfires," *Saf Sci*, vol. 157, p. 105928, 2023, doi: https://doi.org/10.1016/j.ssci.2022.105928.

[82] M. E. Berlyand, "Prediction and regulation of air pollution," *Prediction and regulation of air pollution*, 1991, doi: 10.1007/978-94-011-3768-3.

[83] O. Ritenberga, M. Sofiev, V. Kirillova, L. Kalnina, and E. Genikhovich, "Statistical modelling of non-stationary processes of atmospheric pollution from natural sources: example of birch pollen," *Agric For Meteorol*, vol. 226–227, pp. 96–107, Oct. 2016, doi: 10.1016/J.AGRFORMET.2016.05.016.

[84] O. Ritenberga *et al.*, "A statistical model for predicting the inter-annual variability of birch pollen abundance in Northern and North-Eastern Europe," *Science of The Total Environment*, vol. 615, pp. 228–239, Feb. 2018, doi: 10.1016/J.SCITOTENV.2017.09.061.

[85] U. Berger *et al.*, "Personalized pollen-related symptom-forecast information services for allergic rhinitis patients in Europe," 2013. doi: 10.1111/all.12181.

[86] J. Méndez, P. Comtois, and I. Iglesias, "Betula pollen: One of the most important aeroallergens in Ourense, Spain. Aerobiological studies from 1993 to 2000," *Aerobiologia (Bologna)*, vol. 21, no. 2, pp. 115–124, 2005, doi: 10.1007/s10453-005-4181-0.

[87] K. Masaka and S. Maguchi, "Modelling the Masting Behaviour of Betula platyphylla var. japonica using the Resource Budget Model," *Ann Bot*, vol. 88, no. 6, pp. 1049–1055, Dec. 2001, doi: 10.1006/anbo.2001.1547.

Copyright © FirEURisk Consortium. All rights reserved.

9. Annex A: Stakeholder networks

Table 11. Stakeholder networks list created in demonstration events, webinars, and project events

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
1	Agricultural University of Tirana, Faculty of Forestry Sciences.	Albania	Scientific community	Academia
2	Expert SDG Algeria	Algeria	Industrial	Private company
3	University of Science and Technology Mohamed Boudiaf, USTO-MB	Algeria	Scientific community	Academia
4	Servicio Nacional de Manejo del Fuego, SNMF	Argentina	First responders	Fire Service
5	Brisbane Bushfire Consulting	Australia	Industrial	Private Company
6	NRFC Consulting	Australia	Industrial	Private company
7	Department of Energy, Environment and Climate Action (Victorian State Government)	Australia	Policy and regulation makers	Regional authorities
8	University of Melbourne	Australia	Scientific community	Academia
9	Disaster Competence Network Austria	Austria	First responders	First responders
10	Thayatal National Park	Austria	Landowners / managers	Landowners (public)
11	Bocconi University	Austria	Scientific community	Academia
12	International Institute for Applied Systems Analysis, IIASA	Austria	Scientific community	Research
13	University of Natural Resources and Life Sciences, BOKU	Austria	Scientific community	Academia/Research
14	University of Dhaka	Bangladesh	Scientific community	Academia
15	Bangladesh Gerontological Association, BGA	Bangladesh	Risk prevention communities	Protection organisations
16	Wildfire FT	Belgium	Civil society orgs	NGO
17	Federal University of Ceará	Brazil	Scientific community	Academia
18	DG Fire Safety and Civil Protection. Ministry of Interior	Bulgaria	First responders	Fire Service
19	National Institute of Geophysics, Geodesy and Geography. Bulgarian Academy of Sciences	Bulgaria	Policy and regulation makers	National agencies
20	Forest Research Institute. Bulgarian Academy of Sciences	Bulgaria	First responders	Research
21	United Nations Volunteers (UNV) of Chad	Chad	Scientific community	Academia
22	UN Development Programme, UNDP for Chad	Chad	Policy and regulation makers	Intergovernmental Organization
23	Bomberos de Chile	Chile	First responders	Firefighters
24	Civil Protection Directorate	Croatia	First responders	Civil Protection (National)
25	Micro Digital	Croatia	Industrial	Private company
26	NoveFore	Croatia	Industrial	Private company
27	Resilient Nature	Croatia	Industrial	Private company
28	RiniGARD	Croatia	Industrial	Private company
29	Croatian Meteorological and Hydrological Service, DHMZ	Croatia	Policy and regulation makers	National agencies
30	FESB University of Split	Croatia	Scientific community	Academia
31	University of Zagreb. Faculty of Agriculture	Croatia	Scientific community	Academia

Copyright © FirEURisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
32	FLEVO LTD.	Cyprus	Industrial	Private company
33	European University Cyprus, EUC - Centre of Excellence in Risk and Decision Sciences, CERIDES	Cyprus	Scientific community	Academia
34	Bohemian Switzerland National Park	Czech Republic	First responders	Public landowners
35	Fire and Rescue Services Czech Republic	Czech Republic	First responders	Firefighters
36	Czech State Forest Enterprise	Czech Republic	Landowners / managers	Forest Management
37	Podyji National Park	Czech Republic	Landowners / managers	Landowners (public)
38	Copenhagen Business School	Denmark	Scientific community	Academia
39	Union for the Mediterranean, UfM	Europe	Policy and regulation makers	Intergovernmental Organization
40	European Forest Institute, EFI	Europe	Scientific community	Intergovernmental Organization
41	European Association of Civil Protection Volunteer Teams, EVOLSAR	European Commission	Civil society orgs	Civil Protection (International)
42	Clean Energy Investment Forum, CEIF. DG ENER - Directorate-General for Energy develops and implements EU policy on energy	European Commission	Policy and regulation makers	Policy officer
43	European Commission Joint Research Centre, EC JRC	European Commission	Policy and regulation makers	Research
44	European Commission, EC	European Commission	Policy and regulation makers	Policy officer
45	European Commission. DG ECHO - Directorate-General for European Civil Protection and Humanitarian Aid Operations	European Commission	Policy and regulation makers	Policy officer
46	Finnish Emergency Services Academy	Finland	Scientific community	Academia
47	Finnish Environment Institute, SYKE	Finland	Scientific community	Research
48	an association to prevent forest fires	France	Civil society orgs	NGO
49	Fire station in Marseille (SDIS 13). Fédération nationale des sapeurs-pompiers de France	France	First responders	Firefighters
50	French National Fire Officers Academy, ENSOSP	France	First responders	Fire Training Center
51	Pompiers de l'urgence internationale, PUI	France	First responders	Firefighters
52	AXA	France	Industrial	Insurance
53	ForestGuard	France	Industrial	Private company
54	Ramboll	France	Industrial	Private company
55	COFOR Occitanie Pyrénées-Méditerranée	France	Landowners / managers	Forest Management
56	French National Forests Office - Office National des Forêts, ONF	France	Policy and regulation makers	National agencies
57	Institute of Evolutionary Science of Montpellier, ISEM. EPHE-ProgrammeGraduéSciencesTerreBiodiversité	France	Scientific community	Research
58	National Institute of Agricultural Research - Institut National de la Recherche Agronomique, INRAE	France	Scientific community	Research
59	Testing and Research Center (CEREN, Centre d'Essais et de Recherche de l'Entente Sécurité Civile). Entente pour la Forêt Méditerranéenne, ENTENTE VALABRE	France	Scientific community	Research
60	University of Corsica	France	Scientific community	Academia
61	Warucene	France	Civil society orgs	Fire Risk prevention
62	Fire Service Bouches-du-Rhône	France	First responders	Firefighters

Copyright © FirEUrisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
63	Fire station in Vailhauquès (SDIS34). Fédération nationale des sapeurs-pompiers de France	France	First responders	Firefighters
64	Deutscher Feuerwehrverband, WG Wildfire	Germany	First responders	Firefighters
65	Fire Department Dortmund	Germany	First responders	Fire Service
66	German Firedepartment Association Head of WG Wildfire	Germany	First responders	Firefighters
67	International Disaster Response Germany	Germany	First responders	Civil Protection (National)
68	Dryad Networks GmbH	Germany	Industrial	Private company
69	geomer GmbH	Germany	Industrial	Private company
70	MainFire	Germany	Industrial	Private company
71	OroraTech GmbH	Germany	Industrial	Private company
72	Saxon State Forests	Germany	Landowners / managers	Landowners (public)
73	Eberswalde University for Sustainable Development, HNEE	Germany	Scientific community	Research
74	Education and research for fire fighters	Germany	Scientific community	TrainingFirefighters
75	Fraunhofer Institute for Technological Trend Analysis, INT	Germany	Scientific community	Research
76	German Research Center for Artificial Intelligence	Germany	Scientific community	Research
77	Helmholtz Centre for Environmental Research, UFZ-Leipzig	Germany	Scientific community	Research
78	Humbolt University Berlin	Germany	Scientific community	Research
79	Otto-von-Guericke University	Germany	Scientific community	Academia
80	Senckenberg Biodiversity and Climate Research Centre, SBiK-F	Germany	Scientific community	Research
81	University of Potsdam	Germany	Scientific community	Academia
82	University of Technology, TU	Germany	Scientific community	Academia
83	Working Group Wildfire Germany	Germany	Scientific community	Research
84	Saxon State Fire Brigade	Germany	First responders	Fire Service
85	Brandherde GmbH	Germany	Industrial	Fire Prevention
86	Private Forest Owner	Germany	Landowners / managers	Landowners (private)
87	Saxon Switzerland National Park	Germany	Landowners / managers	Landowners (public)
88	German Weather Service, DWD	Germany	Policy and regulation makers	National agencies
89	Saxon Ministry for Regional Development, SMR	Germany	Policy and regulation makers	Regional authorities
90	Saxon Wildfire 2022 Expert Commission	Germany	Risk prevention communities	Regional
91	Berlin University of Technology, TU Berlin	Germany	Scientific community	Research
92	Fraunhofer Institute for High-Speed Dynamics, EMI	Germany	Scientific community	Research
93	Helmholtz Centre for Environmental Research GmbH	Germany	Scientific community	Research
94	Munich University of Technology, TU Munich	Germany	Scientific community	Research
95	Thünen Institute for Forest Ecosystems	Germany	Scientific community	Research
96	Fire Department	Greece	First responders	Fire Service

Copyright © FirEUrisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
97	Hellenic Fire Corps	Greece	First responders	Firefighters
98	Agricultural University of Athens	Greece	Scientific community	Academia
99	Institute of Mediterranean Forest Ecosystems	Greece	Scientific community	Research
100	National Observatory of Athens, NOA	Greece	Scientific community	Research
101	National Observatory of Athens, NOA - Institute for Environmental Research & Sustainable Development ,IERSD	Greece	Scientific community	Research
102	University of Greenwich	Greece	Scientific community	Academia
103	EDGE in EO Sciences	Greece	Civil society orgs	Communication
104	OMIKRON Ltd	Greece	Industrial	Private company
105	Municipality of Rafina-Pikermi	Greece	Policy and regulation makers	Local authorities
106	Robotics Cats	Hong Kong	Industrial	Private company
107	Hungarian National Directorate General for Disaster Management	Hungary	Policy and regulation makers	National authorities
108	Hungarian National Food Chain Safety Office (forest authority)	Hungary	Policy and regulation makers	National agencies
109	International Institute of Information Technology Hyderabad, IIITH	India	Scientific community	Academia
110	University of Delhi	India	Scientific community	Academia
111	Dell Technologies	Ireland	Industrial	Private company
112	Centro di Alta Formazione Anti Incendi Boschivi e Protezione Civile (Formont) - Corpo Anti Incendi Boschivi del Piemonte	Italy	Civil society orgs	Fire Training Center
113	Civil Protection - Protezione Civile	Italy	First responders	Civil Protection (National)
114	Italian National Fire and Rescue Service - Corpo Nazionale dei Vigili del Fuoco, CNVVF	Italy	First responders	Firefighters
115	Dream Italia	Italy	Industrial	Private company
116	ENGINEERING INGEGNERIA INFORMATICA	Italy	Industrial	Private company
117	Comunità Montana Valli del Verbano	Italy	Landowners / managers	Local authorities
118	Euro-Mediterranean Center on Climate Change, CMCC	Italy	Scientific community	Research
119	LINKS Foundation	Italy	Civil society orgs	NGO
120	Save the Children Italia	Italy	Civil society orgs	NGO
121	Forestry and Environmental Surveillance Corps, CFVA - Sardinia Region	Italy	First responders	Civil Protection (Regional)
122	Mountai Forest Fire Fight & Civil Protection Advanced Training Center	Italy	First responders	Civil Protection (National)
123	Sardinia Civil Protection	Italy	First responders	Fire planning
124	Sardinia Environmental Protection Agency	Italy	First responders	Fire danger monitoring and forecast
125	Sardinia Forest Agency	Italy	First responders	Fire prevention
126	Sardinia Forest Service	Italy	First responders	Fire management and suppression
127	(cyber)security and technological products, solutions and services provider	Italy	Industrial	Private company
128	Ithaca S.r.l.	Italy	Industrial	Private company

Copyright © FirEURisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
129	Zanasi & Partners	Italy	Industrial	Private company
130	Risk forecasting Regione Sardegna	Italy	Policy and regulation makers	Regional authorities
131	Coventry University	Italy	Scientific community	Academia
132	Pegaso University - Università Telematica Pegaso	Italy	Scientific community	Academia
133	University of Genoa	Italy	Scientific community	Academia
134	University of Padua	Italy	Scientific community	Research
135	University of Sassari & Nuoro University	Italy	Scientific community	Academia
136	(A non-profit company licensed in Britain)	Jordan	Civil society orgs	NGO
137	Public Security Directorate / Civil Defense	Jordan	First responders	Civil Protection (National)
138	Lebanese American University	Lebanon	Scientific community	Academia
139	Lithuanian Ministry of the Environment	Lithuania	Policy and regulation makers	National authorities
140	Municipality	Luxembourg	First responders	Local authorities
141	Nature and Forest Agency (Administration de la nature et des forêts, ANF)	Luxembourg	Policy and regulation makers	Forest Service
142	Asia Pacific University	Malaysia	Scientific community	Academia
143	University Malaysia Sabah	Malaysia	Scientific community	Academia
144	Public Enterprise for National Parks of Montenegro	Montenegro	First responders	protection in the national parks of Montenegro
145	Shuklaphanta National Park	Nepal	Landowners / managers	Landowners (public)
146	University of Southern Queensland	Nepal	Scientific community	Research
147	Wildflyer B.V.	Netherlands	Industrial	Private company
148	Government safety organization	Netherlands	Policy and regulation makers	National agencies
149	Free University of Amsterdam, VU	Netherlands	Scientific community	Academia
150	Wageningen University & Research, WUR	Netherlands	Scientific community	Academia
151	Regional Fire Monitoring Center, RFMC	North Macedonia	Policy and regulation makers	National agencies
152	University Goce Delcev Stip, Military academy Skopje.	North Macedonia	Scientific community	Academia
153	University Goce Delcev Stip, Military academy General Mihailo Apostolski Skopje	North Macedonia	Scientific community	Academia
154	Western Norway University of Applied Sciences	Norway	Scientific community	Academia
155	College of the State Fire Service - Szkoła Aspirantów Państwowej Straży Pożarnej	Poland	First responders	Fire Training Center
156	Doctoral School University of the National Education Commission, Krakow	Poland	First responders	Academia
157	Forest Research Institute Poland	Poland	First responders	Research
158	Pedagogical University of Kraków	Poland	Scientific community	Academia
159	Polish Forest Research Institute, IBL	Poland	Scientific community	Forest Management
160	Associação Nacional dos Alistados das Formações Sanitárias, ANAFS	Portugal	Civil society orgs	National authorities
161	Associação SCP Safe Communities Portugal	Portugal	Civil society orgs	NGO

Copyright © FirEUrisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
162	Association Safe Communities Portugal	Portugal	Civil society orgs	Civil communities
163	Bravo Mundo (knowledge community group)	Portugal	Civil society orgs	NGO
164	Mediterranean Forest Union - União da Floresta Mediterrânica, UNAC	Portugal	Civil society orgs	NGO
165	National School of Firefighters - Escola Nacional de Bombeiros, ENB	Portugal	Civil society orgs	ENB is the National Fire Service School of Portugal
166	O Tempo Na Margem Sul	Portugal	Civil society orgs	NGO
167	Safe Communities Portugal	Portugal	Civil society orgs	NGO
168	Agency for the Integrated Management of Rural Fires, I.P. (AGIF)	Portugal	First responders	Civil Protection (National)
169	Associação Portuguesa dos Bombeiros Voluntários, APBV	Portugal	First responders	Firefighters
170	Civil Protection Volunteer Organisation	Portugal	First responders	Civil Protection (National)
171	Comando Distrital de Operações de Socorro de Portalegre, CDOS Portalegre	Portugal	First responders	Civil Protection (Regional)
172	Comando Sub-Regional de Emergência e Proteção Civil do Oeste, CSREPC Oeste	Portugal	First responders	Civil Protection (Regional)
173	Companhia Bombeiros Sapadores de Braga	Portugal	First responders	Firefighters
174	Companhia Bombeiros Sapadores de Viana do Castelo	Portugal	First responders	Firefighters
175	Companhia de Bombeiros Voluntários de Montemor-o-Velho	Portugal	First responders	Firefighters
176	Companhia de Bombeiros Voluntários de Montijo	Portugal	First responders	Firefighters
177	Companhia de Bombeiros Voluntários de Ponte de Lima	Portugal	First responders	Firefighters
178	Criminal Police - Polícia Judiciária	Portugal	First responders	Law enforcement authorities
179	Fire Brigade Firefighters	Portugal	First responders	Firefighters
180	Fire Brigade Firefighters of São Pedro da Cova	Portugal	First responders	Firefighters
181	Fire Brigade Firefighters of Vila Nova de Gaia	Portugal	First responders	Firefighters
182	Fire Brigade Firefighters of Abrantes	Portugal	First responders	Firefighters
183	Fire Brigade Firefighters of Albergaria-a-Velha	Portugal	First responders	Firefighters
184	Fire Brigade Firefighters of Albufeira	Portugal	First responders	Firefighters
185	Fire Brigade Firefighters of Alcabideche	Portugal	First responders	Firefighters
186	Fire Brigade Firefighters of Alcobaça	Portugal	First responders	Firefighters
187	Fire Brigade Firefighters of Alcochete	Portugal	First responders	Firefighters
188	Fire Brigade Firefighters of Alcoutim	Portugal	First responders	Firefighters
189	Fire Brigade Firefighters of Alter do Chão	Portugal	First responders	Firefighters
190	Fire Brigade Firefighters of Arganil	Portugal	First responders	Firefighters
191	Fire Brigade Firefighters of Aveiro Velhos	Portugal	First responders	Firefighters
192	Fire Brigade Firefighters of Barreiro	Portugal	First responders	Firefighters
193	Fire Brigade Firefighters of Belas	Portugal	First responders	Firefighters
194	Fire Brigade Firefighters of Bragança	Portugal	First responders	Firefighters

Copyright © FirEUrisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
195	Fire Brigade Firefighters of Campo de Ourique	Portugal	First responders	Firefighters
196	Fire Brigade Firefighters of Carcavelos S. D. Rana	Portugal	First responders	Firefighters
197	Fire Brigade Firefighters of Carnaxide	Portugal	First responders	Firefighters
198	Fire Brigade Firefighters of Condeixa	Portugal	First responders	Firefighters
199	Fire Brigade Firefighters of Ermesinde	Portugal	First responders	Firefighters
200	Fire Brigade Firefighters of Faro	Portugal	First responders	Firefighters
201	Fire Brigade Firefighters of Ferreira do Alentejo	Portugal	First responders	Firefighters
202	Fire Brigade Firefighters of Gondomar	Portugal	First responders	Firefighters
203	Fire Brigade Firefighters of Machico	Portugal	First responders	Firefighters
204	Fire Brigade Firefighters of Mangualde	Portugal	First responders	Firefighters
205	Fire Brigade Firefighters of Matosinhos Leça	Portugal	First responders	Firefighters
206	Fire Brigade Firefighters of Monchique	Portugal	First responders	Firefighters
207	Fire Brigade Firefighters of Montemor.o.Novo	Portugal	First responders	Firefighters
208	Fire Brigade Firefighters of Moscavide e Portela	Portugal	First responders	Firefighters
209	Fire Brigade Firefighters of Nazaré	Portugal	First responders	Firefighters
210	Fire Brigade Firefighters of Pedrógão Grande	Portugal	First responders	Firefighters
211	Fire Brigade Firefighters of Pombal	Portugal	First responders	Firefighters
212	Fire Brigade Firefighters of Póvoa de Santa Iria	Portugal	First responders	Firefighters
213	Fire Brigade Firefighters of Sacavém	Portugal	First responders	Firefighters
214	Fire Brigade Firefighters of Silves	Portugal	First responders	Firefighters
215	Fire Brigade Firefighters of Tomar	Portugal	First responders	Firefighters
216	Fire Brigade Firefighters of Trofa	Portugal	First responders	Firefighters
217	Fire Brigade Firefighters of Viana do Alentejo	Portugal	First responders	Firefighters
218	Firefighters Regiment	Portugal	First responders	Firefighters
219	Forestry, Civil Protection and Fire Technical Office of Sardoal - Gabinete Proteção Civil, Florestal e Bombeiros de Sardoal	Portugal	First responders	Civil Protection (Local)
220	Humanitarian Association of Voluntary Firefighters of São Pedro de Sintra	Portugal	First responders	Firefighters
221	Humanitarian Association of Voluntary Firefighters of Agualva-Cacém	Portugal	First responders	Firefighters
222	Humanitarian Association of Voluntary Firefighters of Ajuda	Portugal	First responders	Firefighters
223	Humanitarian Association of Voluntary Firefighters of Albufeira	Portugal	First responders	Firefighters
224	Humanitarian Association of Voluntary Firefighters of Alcabideche em Cascais	Portugal	First responders	Firefighters
225	Humanitarian Association of Voluntary Firefighters of Algés	Portugal	First responders	Firefighters
226	Humanitarian Association of Voluntary Firefighters of Aljezur	Portugal	First responders	Firefighters
227	Humanitarian Association of Voluntary Firefighters of Almeirim	Portugal	First responders	Firefighters
228	Humanitarian Association of Voluntary Firefighters of Barreiro C.S.P.	Portugal	First responders	Firefighters
229	Humanitarian Association of Voluntary Firefighters of Cadaval	Portugal	First responders	Firefighters

Copyright © FirEUrisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
230	Humanitarian Association of Voluntary Firefighters of Câmara de Lobos	Portugal	First responders	Firefighters
231	Humanitarian Association of Voluntary Firefighters of Camarate	Portugal	First responders	Firefighters
232	Humanitarian Association of Voluntary Firefighters of Carcavelos e S. Domingos Rana	Portugal	First responders	Firefighters
233	Humanitarian Association of Voluntary Firefighters of Carregal do Sal	Portugal	First responders	Firefighters
234	Humanitarian Association of Voluntary Firefighters of Castro Daire	Portugal	First responders	Firefighters
235	Humanitarian Association of Voluntary Firefighters of Caxarias	Portugal	First responders	Firefighters
236	Humanitarian Association of Voluntary Firefighters of Feira	Portugal	First responders	Firefighters
237	Humanitarian Association of Voluntary Firefighters of Fontes	Portugal	First responders	Firefighters
238	Humanitarian Association of Voluntary Firefighters of Guarda	Portugal	First responders	Firefighters
239	Humanitarian Association of Voluntary Firefighters of Lamego	Portugal	First responders	Firefighters
240	Humanitarian Association of Voluntary Firefighters of Leiria	Portugal	First responders	Firefighters
241	Humanitarian Association of Voluntary Firefighters of Leixoes	Portugal	First responders	Firefighters
242	Humanitarian Association of Voluntary Firefighters of Lisbonenses	Portugal	First responders	Firefighters
243	Humanitarian Association of Voluntary Firefighters of Maceira	Portugal	First responders	Firefighters
244	Humanitarian Association of Voluntary Firefighters of Malveira / Ambex	Portugal	First responders	Firefighters
245	Humanitarian Association of Voluntary Firefighters of Mangualde	Portugal	First responders	Firefighters
246	Humanitarian Association of Voluntary Firefighters of Melo	Portugal	First responders	Firefighters
247	Humanitarian Association of Voluntary Firefighters of Merceana	Portugal	First responders	Firefighters
248	Humanitarian Association of Voluntary Firefighters of Miranda do Corvo	Portugal	First responders	Firefighters
249	Humanitarian Association of Voluntary Firefighters of Monchique	Portugal	First responders	Firefighters
250	Humanitarian Association of Voluntary Firefighters of Moscavide e Portela	Portugal	First responders	Firefighters
251	Humanitarian Association of Voluntary Firefighters of Oliveira do Hospital	Portugal	First responders	Firefighters
252	Humanitarian Association of Voluntary Firefighters of Ovar	Portugal	First responders	Firefighters
253	Humanitarian Association of Voluntary Firefighters of Penedono	Portugal	First responders	Firefighters
254	Humanitarian Association of Voluntary Firefighters of Portimão	Portugal	First responders	Firefighters
255	Humanitarian Association of Voluntary Firefighters of Povoa de Santa Iria	Portugal	First responders	Firefighters
256	Humanitarian Association of Voluntary Firefighters of Póvoa de Santa Iria	Portugal	First responders	Firefighters
257	Humanitarian Association of Voluntary Firefighters of Ribeira Brava e Ponta do Sol	Portugal	First responders	Firefighters
258	Humanitarian Association of Voluntary Firefighters of S.P e Cruz Branca de Vila Real	Portugal	First responders	Firefighters
259	Humanitarian Association of Voluntary Firefighters of Sacavém	Portugal	First responders	Firefighters
260	Humanitarian Association of Voluntary Firefighters of Seixal	Portugal	First responders	Firefighters
261	Humanitarian Association of Voluntary Firefighters of Silves	Portugal	First responders	Firefighters
262	Humanitarian Association of Voluntary Firefighters of Sobral	Portugal	First responders	Firefighters
263	Humanitarian Association of Voluntary Firefighters of Sul e Sueste, AHBVSS	Portugal	First responders	Firefighters
264	Humanitarian Association of Voluntary Firefighters of Tondela	Portugal	First responders	Firefighters

Copyright © FirEUrisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
265	Humanitarian Association of Voluntary Firefighters of Torres Novas	Portugal	First responders	Firefighters
266	Humanitarian Association of Voluntary Firefighters of Valongo	Portugal	First responders	Firefighters
267	Humanitarian Association of Voluntary Firefighters of Viana do Castelo	Portugal	First responders	Firefighters
268	Humanitarian Association of Voluntary Firefighters of Vila franca das Naves	Portugal	First responders	Firefighters
269	Humanitarian Association of Voluntary Firefighters of Vila Nova de Milfontes	Portugal	First responders	Firefighters
270	Humanitarian Association of Voluntary Firefighters of Vila Real Cruz Verde	Portugal	First responders	Firefighters
271	Institute for Nature Conservation and Forests - Instituto da Conservação da Natureza e das Florestas, ICNF	Portugal	First responders	Firefighters
272	Lisbon Firefighters Regiment	Portugal	First responders	Firefighters
273	Local Civil Protection - Unidade Local de Proteção Civil, ULPC	Portugal	First responders	Civil Protection (Local)
274	Municipal Civil Protection	Portugal	First responders	Civil Protection (Local)
275	Municipal Civil Protection - Serviço Municipal de Proteção Civil, SMPC	Portugal	First responders	Civil Protection (Local)
276	Municipal Civil Protection and Forest Protection of Valongo	Portugal	First responders	Civil Protection (Local)
277	Municipal Civil Protection of Castanheira de Pera	Portugal	First responders	Civil Protection (Local)
278	Municipal Civil Protection of Castro Marim	Portugal	First responders	Civil Protection (Local)
279	Municipal Civil Protection of Coruche	Portugal	First responders	Civil Protection (Local)
280	Municipal Civil Protection of Faro	Portugal	First responders	Civil Protection (Local)
281	Municipal Civil Protection of Figueira da Foz	Portugal	First responders	Civil Protection (Local)
282	Municipal Civil Protection of Guimarães	Portugal	First responders	Civil Protection (Local)
283	Municipal Civil Protection of Loulé	Portugal	First responders	Civil Protection (Local)
284	Municipal Civil Protection of Loures	Portugal	First responders	Civil Protection (Local)
285	Municipal Civil Protection of Mafra	Portugal	First responders	Civil Protection (Local)
286	Municipal Civil Protection of Montijo	Portugal	First responders	Civil Protection (Local)
287	Municipal Civil Protection of Portimão	Portugal	First responders	Civil Protection (Local)
288	Municipal Civil Protection of Porto	Portugal	First responders	Civil Protection (Local)
289	Municipal Civil Protection of Tavira	Portugal	First responders	Civil Protection (Local)
290	Municipal Civil Protection of Vila Nova de Poiares	Portugal	First responders	Civil Protection (Local)
291	Municipal Civil Protection of Vila Real de Santo António	Portugal	First responders	Civil Protection (Local)
292	Municipal Fire Department of Alcanena	Portugal	First responders	Firefighters
293	Municipal Fire Department of Coruche	Portugal	First responders	Firefighters
294	Municipal Fire Department of Loulé	Portugal	First responders	Firefighters
295	Municipal Fire Department of Lousã	Portugal	First responders	Firefighters
296	National Authority for Emergency and Civil Protection - Autoridade Nacional de Emergência e Proteção Civil, ANEPC	Portugal	First responders	Civil Protection (National)
297	National Authority for Emergency and Civil Protection - Autoridade Nacional de Emergência e Proteção Civil, ANEPC |FEPCipma	Portugal	First responders	Civil Protection (National)
298	National Authority for Emergency and Civil Protection - Autoridade Nacional de Emergência e Proteção Civil, ANEPC |Grupo de Análise e Uso do Fogo (GAUF)	Portugal	First responders	Civil Protection (National)

Copyright © FirEURisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
299	National Republican Guard - Guarda Nacional Republicana, GNR	Portugal	First responders	Law enforcement authorities
300	National Republican Guard - Guarda Nacional Republicana, GNR |Emergency Protection and Relief Unit, UEPS	Portugal	First responders	Law enforcement authorities
301	National Republican Guard - Guarda Nacional Republicana, GNR |Nature and Environment Protection Service, SEPNA	Portugal	First responders	Law enforcement authorities
302	Portuguese Air Force, FAP Força Aérea Portuguesa	Portugal	First responders	Law enforcement authorities
303	Portuguese Army	Portugal	First responders	Law enforcement authorities
304	Portuguese Army - OPSAS	Portugal	First responders	Law enforcement authorities
305	Portuguese Army - Secção combate a Incêndios Assistência e Socorro - AMT - Tancos	Portugal	First responders	Law enforcement authorities
306	Portuguese Red Cross	Portugal	First responders	Red Cross
307	Regional Civil Protection - Serviço Regional de Proteção Civil	Portugal	First responders	Civil Protection (Regional)
308	Special Civil Protection Force - Força Especial de Proteção Civil	Portugal	First responders	Civil Protection (National)
309	Special Civil Protection Force - Força Especial de Proteção Civil. Grupo de Análise e Uso do Fogo	Portugal	First responders	Civil Protection (National)
310	Special Civil Protection Force, FEPC	Portugal	First responders	Civil Protection (National)
311	Special Civil Protection Force, FEPC - National Authority for Emergency and Civil Protection, ANEPC	Portugal	First responders	Civil Protection (National)
312	Special Civil Protection Force, FEPC - Use of Fire and Analysis Group, GAUF	Portugal	First responders	Civil Protection (National)
313	Volunteer Firefighters	Portugal	First responders	Firefighters
314	Volunteer Firefighters of Albufeira	Portugal	First responders	Firefighters
315	Volunteer Firefighters of Aljezur	Portugal	First responders	Firefighters
316	Volunteer Firefighters of Arganil	Portugal	First responders	Firefighters
317	Volunteer Firefighters of Azambuja	Portugal	First responders	Firefighters
318	Volunteer Firefighters of Benedita	Portugal	First responders	Firefighters
319	Volunteer Firefighters of Braga subchefe Nascimento	Portugal	First responders	Firefighters
320	Volunteer Firefighters of Camarate	Portugal	First responders	Firefighters
321	Volunteer Firefighters of Cantanhede	Portugal	First responders	Firefighters
322	Volunteer Firefighters of Carcavelos	Portugal	First responders	Firefighters
323	Volunteer Firefighters of Carvalhos	Portugal	First responders	Firefighters
324	Volunteer Firefighters of Castelo de Vide	Portugal	First responders	Firefighters
325	Volunteer Firefighters of Coimbra	Portugal	First responders	Firefighters
326	Volunteer Firefighters of Coimbra	Portugal	First responders	Firefighters
327	Volunteer Firefighters of Coimbrões	Portugal	First responders	Firefighters
328	Volunteer Firefighters of Crestuma	Portugal	First responders	Firefighters
329	Volunteer Firefighters of Esmoriz	Portugal	First responders	Firefighters
330	Volunteer Firefighters of Fajões	Portugal	First responders	Firefighters

Copyright © FirEUrisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
331	Volunteer Firefighters of Fundão	Portugal	First responders	Firefighters
332	Volunteer Firefighters of Fundão	Portugal	First responders	Firefighters
333	Volunteer Firefighters of Guarda	Portugal	First responders	Firefighters
334	Volunteer Firefighters of Lourinhã	Portugal	First responders	Firefighters
335	Volunteer Firefighters of Malveira / Ambex Equipamentos Lda	Portugal	First responders	Firefighters
336	Volunteer Firefighters of Montelavar	Portugal	First responders	Firefighters
337	Volunteer Firefighters of Ovar	Portugal	First responders	Firefighters
338	Volunteer Firefighters of Penela	Portugal	First responders	Firefighters
339	Volunteer Firefighters of Setúbal	Portugal	First responders	Firefighters
340	Volunteer Firefighters of Silves	Portugal	First responders	Firefighters
341	Volunteer Firefighters of Silves	Portugal	First responders	Firefighters
342	Volunteer Firefighters of Trofa	Portugal	First responders	Firefighters
343	Volunteer Firefighters of Vila Meã	Portugal	First responders	Firefighters
344	Volunteer Firefighters of Vinhais	Portugal	First responders	Firefighters
345	Rui Manuel Álvaro Monteiro	Portugal	General public	General public
346	National Institute of Health, Porto, Portugal	Portugal	Hospital/medical	National agencies
347	Portuguese Research Centre for Sustainable Chemistry, REQUIMTE-LAQV-ISEP	Portugal	Hospital/medical	Research
348	University of Coimbra, UC. Faculty of Medicine	Portugal	Hospital/medical	Academia
349	Pro Safety Lda	Portugal	Industrial	Private company
350	ACBGC	Portugal	Industrial	Private company
351	Altri Group	Portugal	Industrial	Private company
352	Aquaform	Portugal	Industrial	Private company
353	AQUALOGUS, Engenharia e Ambiente	Portugal	Industrial	Private company
354	Associação de Municípios para a Gestão Sustentável de Resíduos do Grande Porto, LIPOR	Portugal	Industrial	Private company
355	Associação de Radioamadores da Costa de Prata, ARCP	Portugal	Industrial	Private company
356	Associação de Radioamadores da Costa de Prata, CS1ACP	Portugal	Industrial	Private company
357	CIGeoE, Portugal	Portugal	Industrial	Private Company
358	DS Smith Paper Viana, S.A.	Portugal	Industrial	Private company
359	Florecha SA	Portugal	Industrial	Private company
360	ForestWISE CoLab	Portugal	Industrial	Company
361	GeoAtributo CIPOT, Lda	Portugal	Industrial	Private company
362	Hubriss System ID	Portugal	Industrial	Private company
363	La Lusa - Agência de Notícias de Portugal, S.A.	Portugal	Industrial	Private company
364	Leitek Innovative Solutions	Portugal	Industrial	Private company
365	Mário Loureiro Engenharia Lda	Portugal	Industrial	Private company

Copyright © FirEURisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
366	Mons Consulting	Portugal	Industrial	Private company
367	MoreColab	Portugal	Industrial	Private company
368	NVG	Portugal	Industrial	Private company
369	P&C Insurer	Portugal	Industrial	Insurance
370	Rede Operacional de Comunicações de Coimbra	Portugal	Industrial	Private company
371	Simbiente Açores - Engenharia E Gestão Ambiental, Lda.	Portugal	Industrial	Private company
372	SMEs of Portugal - Pequenas e Médias Empresas de Portugal, PME	Portugal	Industrial	SME
373	Technological Centre for the Textile and Clothing Industry of Portugal, CITEVE	Portugal	Industrial	Private company
374	Tecniquitel - Sociedade de Equipmentos Tecnicos, SA	Portugal	Industrial	Private company
375	Adega Cooperativa de Cantanhede	Portugal	Landowners / managers	Landowners (private)
376	Ascendi	Portugal	Landowners / managers	Private company
377	Associação de Proteção Civil , APROSOC	Portugal	Landowners / managers	Civil Protection (National)
378	Associação Florestal do Grande Porto, Portucalea	Portugal	Landowners / managers	Landowners (public)
379	Associação para o Ordenamento da Serra da Cabreira, APOSC	Portugal	Landowners / managers	Regional authorities
380	BRISA Operação & Manutenção SA	Portugal	Landowners / managers	Private company
381	Cascais Ambiente	Portugal	Landowners / managers	Local authorities
382	Centro Operativo Tecnológico Hortofrutícola Nacional - Centro de Competências, COTHN-CC	Portugal	Landowners / managers	National agencies
383	CMO	Portugal	Landowners / managers	?
384	EDP Energias de Portugal, S.A.	Portugal	Landowners / managers	Private company
385	EMAC	Portugal	Landowners / managers	?
386	Empresa Municipal de Desenvolvimento Rural de Vinhais, PRORURIS EM	Portugal	Landowners / managers	Landowners (public)
387	E-REDES Distribuição de Eletricidade, S.A.	Portugal	Landowners / managers	Private company
388	E-REDES Distribuição de Energia, S.A.	Portugal	Landowners / managers	Private company
389	FNAPF	Portugal	Landowners / managers	?
390	Forestry Technical Office - Gabinete Técnico Florestal, GTF	Portugal	Landowners / managers	Landowners (public)
391	Forestry Technical Office of Mafra - Gabinete Técnico Florestal, GTF, de Mafra	Portugal	Landowners / managers	Landowners (public)
392	Intermunicipal Community of Baixo Alentejo, CIMBAL	Portugal	Landowners / managers	Regional authorities
393	Intermunicipal Community of Beira Baixa	Portugal	Landowners / managers	Regional authorities
394	Intermunicipal Community of Oeste	Portugal	Landowners / managers	Regional authorities
395	Intermunicipal Community ofs Beiras e Serra da Estrela, CIMBSE	Portugal	Landowners / managers	Regional authorities

Copyright © FirEURisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
396	Junta de Freguesia de Alvaiázere	Portugal	Landowners / managers	Local authorities
397	Municipal Civil Protection of Odivelas	Portugal	Landowners / managers	Civil Protection (Local)
398	Municipal Council of Águed	Portugal	Landowners / managers	Local authorities
399	Municipal Council of Alenquer	Portugal	Landowners / managers	Local authorities
400	Municipal Council of Alijó	Portugal	Landowners / managers	Local authorities
401	Municipal Council of Aljustrel	Portugal	Landowners / managers	Local authorities
402	Municipal Council of Alvito	Portugal	Landowners / managers	Local authorities
403	Municipal Council of Arcos de Valdevez	Portugal	Landowners / managers	Local authorities
404	Municipal Council of Arouca	Portugal	Landowners / managers	Local authorities
405	Municipal Council of Basto	Portugal	Landowners / managers	Local authorities
406	Municipal Council of Braga	Portugal	Landowners / managers	Local authorities
407	Municipal Council of Cadaval	Portugal	Landowners / managers	Local authorities
408	Municipal Council of Caldas da Rainha	Portugal	Landowners / managers	Local authorities
409	Municipal Council of Castanheira de Pera	Portugal	Landowners / managers	Local authorities
410	Municipal Council of Castanheira de Pera	Portugal	Landowners / managers	Local authorities
411	Municipal Council of Castelo Branco	Portugal	Landowners / managers	Local authorities
412	Municipal Council of Coimbra	Portugal	Landowners / managers	Local authorities
413	Municipal Council of Coimbra - SMPC	Portugal	Landowners / managers	Local authorities
414	Municipal Council of Coruche	Portugal	Landowners / managers	Local authorities
415	Municipal Council of Esposende	Portugal	Landowners / managers	Local authorities
416	Municipal Council of Estremoz	Portugal	Landowners / managers	Local authorities
417	Municipal Council of Faro	Portugal	Landowners / managers	Local authorities
418	Municipal Council of Ferreira do Alentejo	Portugal	Landowners / managers	Local authorities
419	Municipal Council of Figueira da Foz	Portugal	Landowners / managers	Local authorities
420	Municipal Council of Figueiró dos Vinhos	Portugal	Landowners / managers	Local authorities
421	Municipal Council of Freixo de Espada à Cinta	Portugal	Landowners / managers	Local authorities
422	Municipal Council of Funchal	Portugal	Landowners / managers	Local authorities
423	Municipal Council of Góis	Portugal	Landowners / managers	Local authorities
424	Municipal Council of Góis - SMPC	Portugal	Landowners / managers	Local authorities

Copyright © FirEURisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
425	Municipal Council of Guarda	Portugal	Landowners / managers	Local authorities
426	Municipal Council of Leiria	Portugal	Landowners / managers	Local authorities
427	Municipal Council of Lisboa	Portugal	Landowners / managers	Local authorities
428	Municipal Council of Loule	Portugal	Landowners / managers	Local authorities
429	Municipal Council of Loulé	Portugal	Landowners / managers	Local authorities
430	Municipal Council of Loule - Gabinete Técnico Florestal	Portugal	Landowners / managers	Local authorities
431	Municipal Council of Loulé - SMPC	Portugal	Landowners / managers	Local authorities
432	Municipal Council of Loures	Portugal	Landowners / managers	Local authorities
433	Municipal Council of Lousã	Portugal	Landowners / managers	Local authorities
434	Municipal Council of Mangualde	Portugal	Landowners / managers	Local authorities
435	Municipal Council of Melgaço	Portugal	Landowners / managers	Local authorities
436	Municipal Council of Montijo	Portugal	Landowners / managers	Local authorities
437	Municipal Council of Montijo - GTF intermunicipal Alcochete e Montijo	Portugal	Landowners / managers	Local authorities
438	Municipal Council of Nazaré	Portugal	Landowners / managers	Local authorities
439	Municipal Council of Odemira	Portugal	Landowners / managers	Local authorities
440	Municipal Council of Odivelas	Portugal	Landowners / managers	Local authorities
441	Municipal Council of Oleiros	Portugal	Landowners / managers	Local authorities
442	Municipal Council of Ourique	Portugal	Landowners / managers	Local authorities
443	Municipal Council of Paços de Ferreira	Portugal	Landowners / managers	Local authorities
444	Municipal Council of Pedras de Fogo	Portugal	Landowners / managers	Local authorities
445	Municipal Council of Pedrógão Grande	Portugal	Landowners / managers	Local authorities
446	Municipal Council of Ponte de Sor	Portugal	Landowners / managers	Local authorities
447	Municipal Council of Portimão	Portugal	Landowners / managers	Local authorities
448	Municipal Council of Porto	Portugal	Landowners / managers	Local authorities
449	Municipal Council of ribeira de Pena	Portugal	Landowners / managers	Local authorities
450	Municipal Council of Santa Maria da Feira	Portugal	Landowners / managers	Local authorities
451	Municipal Council of Santa Marta de Penaguião	Portugal	Landowners / managers	Local authorities
452	Municipal Council of São Brás de Alportel	Portugal	Landowners / managers	Local authorities
453	Municipal Council of Setúbal - Serviço Municipal de Proteção Civil	Portugal	Landowners / managers	Local authorities

Copyright © FirEUrisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
454	Municipal Council of Sintra	Portugal	Landowners / managers	Local authorities
455	Municipal Council of Sobral de Monte Agraço - GTF	Portugal	Landowners / managers	Local authorities
456	Municipal Council of Tábua	Portugal	Landowners / managers	Local authorities
457	Municipal Council of Tábua	Portugal	Landowners / managers	Local authorities
458	Municipal Council of Tavira	Portugal	Landowners / managers	Local authorities
459	Municipal Council of Tomar	Portugal	Landowners / managers	Local authorities
460	Municipal Council of Tondela	Portugal	Landowners / managers	Local authorities
461	Municipal Council of Trancoso	Portugal	Landowners / managers	Local authorities
462	Municipal Council of Trofa	Portugal	Landowners / managers	Local authorities
463	Municipal Council of Valongo	Portugal	Landowners / managers	Local authorities
464	Municipal Council of Valpaços	Portugal	Landowners / managers	Local authorities
465	Municipal Council of Viana do Castelo	Portugal	Landowners / managers	Local authorities
466	Municipal Council of Vidigueira - GTF	Portugal	Landowners / managers	Local authorities
467	Municipal Council of Vila do Conde	Portugal	Landowners / managers	Local authorities
468	Municipal Council of Vila Franca de Xira	Portugal	Landowners / managers	Local authorities
469	Municipal Council of Vila Nova da Barquinha	Portugal	Landowners / managers	Local authorities
470	Municipal Council of Vila Nova de Famalicão	Portugal	Landowners / managers	Local authorities
471	Municipal Council of Vila Nova de Gaia	Portugal	Landowners / managers	Local authorities
472	Municipal Council of Vila Nova de Poiares	Portugal	Landowners / managers	Local authorities
473	Municipal Council of Viseu	Portugal	Landowners / managers	Local authorities
474	Municipal Council of Viseu - CBS	Portugal	Landowners / managers	Local authorities
475	Redes Energéticas Nacionais, REN	Portugal	Landowners / managers	Private company
476	Regional Development Association of Serra do Açor, ADESA	Portugal	Landowners / managers	Regional Association for Developmnet
477	Sonae Arauco SA	Portugal	Landowners / managers	Private company
478	Terrenos baldios	Portugal	Landowners / managers	Local authorities
479	The Navigator Company	Portugal	Landowners / managers	Private company
480	Virtual Operations Support Teams, VOST Portugal	Portugal	Other	Research
481	Associação Nacional de Municípios Portugueses, ANMP	Portugal	Policy and regulation makers	Local authorities
482	Centro de Estudos em Geografia e Ordenamento do Território, CEGOT of University of Coimbra and University of Porto	Portugal	Policy and regulation makers	Academia

Copyright © FirEURisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
483	Centro Portugal Regional Coordination and Development Commission, CCDRC	Portugal	Policy and regulation makers	Regional authorities
484	Direção Regional da Conservação da Natureza e Florestas do Algarve	Portugal	Policy and regulation makers	Regional authorities
485	Direção Regional de Agricultura e Pescas do Centro, DRAPC	Portugal	Policy and regulation makers	Regional authorities
486	Direção Regional de Agricultura e Pescas do Norte, DRAPN	Portugal	Policy and regulation makers	Regional authorities
487	Direção Regional do Ambiente e Ação Climática, DRAAC	Portugal	Policy and regulation makers	Regional authorities
488	Direção Regional do Ambiente e Alterações Climáticas	Portugal	Policy and regulation makers	Regional authorities
489	Direção-Geral do Território, DGT	Portugal	Policy and regulation makers	National agencies
490	Environmental Agency of Portugal	Portugal	Policy and regulation makers	National agencies
491	FAF - Advogados	Portugal	Policy and regulation makers	Private company
492	Instituto Português do Mar e da Atmosfera, IPMA	Portugal	Policy and regulation makers	National agencies
493	Intermunicipal Community of Alentejo Central	Portugal	Policy and regulation makers	Regional authorities
494	Intermunicipal Community of Alto Minho	Portugal	Policy and regulation makers	Regional authorities
495	Intermunicipal Community of Alto Tâmega e Barroso, CIMAT	Portugal	Policy and regulation makers	Regional authorities
496	Intermunicipal Community of Cávado, CIM Cávado	Portugal	Policy and regulation makers	Regional authorities
497	Intermunicipal Community of Douro	Portugal	Policy and regulation makers	Regional authorities
498	Intermunicipal Community of Lezíria do Tejo	Portugal	Policy and regulation makers	Regional authorities
499	Intermunicipal Community of Região de Coimbra, CIM	Portugal	Policy and regulation makers	Regional authorities
500	Intermunicipal Community of Região de Leiria, CIMRL	Portugal	Policy and regulation makers	Regional authorities
501	Intermunicipal Community of Tâmega e Sousa, CIM-TS	Portugal	Policy and regulation makers	Regional authorities
502	National Institute of Health/ EPIUnit-Instituto de Saúde Pública da Universidade do Porto	Portugal	Policy and regulation makers	National agencies
503	Norte Portugal Regional Coordination and Development Commission, CCDR-N	Portugal	Policy and regulation makers	Regional authorities
504	Portugese Ministry of Culture	Portugal	Policy and regulation makers	National authorities
505	Sub-region - Área Metropolitana do Porto (belongs to the North region of Portugal)	Portugal	Policy and regulation makers	Regional authorities
506	Escola Profissional Amar Terra Verde, EPATV	Portugal	Risk prevention communities	Fire Prevention
507	Intermunicipal Community of Algarve, AMAL	Portugal	Risk prevention communities	Regional authorities
508	Institute for Research and Technological Development in Construction, Energy, Environment and Sustainability (Itecons)	Portugal	Scientific community	Research
509	Agricultural School of Ponte de Lima, ESA-IPVC	Portugal	Scientific community	Academia
510	Agrupamento de Escolas de Carregal do Sal	Portugal	Scientific community	Academia
511	Castelo Branco Polytechnic Institute, ESA-IPCB	Portugal	Scientific community	Academia
512	Centre for Ecology, Evolution and Environmental Changes, CE3C	Portugal	Scientific community	Research

Copyright © FirEURisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
513	Centre for Environmental and Marine Studies, CESAM of University of Aveiro, UA	Portugal	Scientific community	Research
514	Centre for Nanotechnology and Smart Materials	Portugal	Scientific community	Research
515	Centro de Estudos e Intervenção em Proteção Civil	Portugal	Scientific community	Research
516	Early Wildfire Detection Technologies	Portugal	Scientific community	?
517	Faculdade de Ciências da Universidade de Lisboa	Portugal	Scientific community	Academia
518	Higher Institute of Education and Sciences of Lisboa, ISEC Lisboa	Portugal	Scientific community	Academia
519	Institute of Information Sciences and Administration (ISCIA, Instituto Superior de Ciências da Informação e da Administração)	Portugal	Scientific community	Academia
520	Institute of Science and Innovation in Mechanical and Industrial Engineering, INEGI	Portugal	Scientific community	Research
521	Instituto Politécnico de Tomar, IPT	Portugal	Scientific community	Academia
522	Instituto Superior de Agronomia, ISA - Centro de Ecologia Aplicada "Prof. Baeta Neves", CEABN of University of Lisbon, ULisboa	Portugal	Scientific community	Research
523	Instituto Superior de Agronomia, ISA - Centro de Estudos Florestais, CEF of University of Lisbon, Ulisboa	Portugal	Scientific community	Research
524	Instituto Superior de Engenharia de Lisboa - ISEL	Portugal	Scientific community	Research
525	Instituto Superior Técnico, IST	Portugal	Scientific community	Academia
526	Linking Landscape, Environment, Agriculture and Food Research Centre, LEAF. School of Agriculture (ISA, Instituto Superior de Agronomia)	Portugal	Scientific community	Research
527	Polytechnic Institute of Bragança, IPB	Portugal	Scientific community	Academia
528	Polytechnic Institute of Coimbra, IPC	Portugal	Scientific community	Academia
529	Polytechnic Institute of Tomar, IPT	Portugal	Scientific community	Academia
530	Polytechnic Institute of Viana do Castelo, IPVC. Escola Superior de Tecnologia e Gestão , ESTG	Portugal	Scientific community	Academia
531	Polytechnical Institute of Coimbra, IPC. Escola Superior Agrária de Coimbra, ESAC	Portugal	Scientific community	Academia
532	Portuguese Research Centre for Sustainable Chemistry, REQUIMTE-LAQV	Portugal	Scientific community	Academia
533	RAIZ	Portugal	Scientific community	Research
534	Research Centre in Biodiversity and Genetic Resources, CIBIO-InBIO	Portugal	Scientific community	Research
535	Research Centre in Biodiversity and Genetic Resources, CIBIO-InBIO/BIOPOLIS	Portugal	Scientific community	Research
536	Research Centre in Biodiversity and Genetic Resources, CIBIO-InBIO/FCUP	Portugal	Scientific community	Research
537	School of Technology and Management of Viseu, IPV-ESTGV	Portugal	Scientific community	Academia
538	Technical University of Lisbon. School of Agriculture (ISA, Instituto Superior de Agronomia)	Portugal	Scientific community	Research
539	Universidade Atlântica/ BV Malveira/ Ambex Equipamentos Lda	Portugal	Scientific community	Academia
540	University of Algarve	Portugal	Scientific community	Academia
541	University of Coimbra Institute for Legal Research, UCILeR	Portugal	Scientific community	Academia
542	University of Coimbra, Instituto Jurídico	Portugal	Scientific community	Academia
543	University of Coimbra, UC. Faculty of Economics	Portugal	Scientific community	Academia
544	University of Coimbra. Faculty of Sciences and Technology, FCTUC	Portugal	Scientific community	Academia
545	University of Évora	Portugal	Scientific community	Academia
546	University of Lisbon	Portugal	Scientific community	Academia

Copyright © FirEURisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
547	University of Lisbon, Ulisboa. Institute of Geography and Spatial Planning, IGOT.	Portugal	Scientific community	Academia
548	University of Lisbon. Faculty of Sciences	Portugal	Scientific community	Academia
549	University of Lisbon. Institute of Geography and Spatial Planning.	Portugal	Scientific community	Academia
550	University of Minho, UMinho	Portugal	Scientific community	Academia
551	University of Minho. Department of Geography	Portugal	Scientific community	Academia
552	University of Porto	Portugal	Scientific community	Academia
553	University of Porto. Faculty of Arts.	Portugal	Scientific community	Academia
554	University of Porto. Faculdade de Letras da Universidade do Porto, FLUP	Portugal	Scientific community	Academia
555	University of Porto. Faculty of Medicine	Portugal	Scientific community	Academia
556	University of Santiago de Compostela; Republican National Guard/SEPNA	Portugal	Scientific community	Academia
557	University of Trás-os-Montes and Alto Douro, UTAD	Portugal	Scientific community	Academia
558	Romanian Ministery of Environment Waters and Forests	Romania	Policy and regulation makers	National authorities
559	Tomsk State University	Russia	Scientific community	Academia
560	NEOM	Saudi Arabia	Industrial	Private company
561	Institute of Informatics of the Slovak Academy of Science	Slovakia	Scientific community	Academia
562	University of Maribor. Faculty of Criminal Justice and Security	Slovenia	Scientific community	Academia
563	Slovenian Forestry Institute	Slovenia	Landowners / managers	Forest Management
564	Pau Costa Foundation	Spain	Civil society orgs	NGO, Foundation
565	Pau Costa Foundation	Spain	Civil society orgs	NGO, Foundation
566	Andalusian Wildfire Service, INFOCA (Incendios Forestales de Andalucía)	Spain	First responders	Fire Service
567	Firefighters of Barcelona	Spain	First responders	Firefighters
568	Military Emergencies Unit, UME	Spain	First responders	Law enforcement authorities
569	Spanish Air Force - 43th Firefighting Group	Spain	First responders	Firefighters
570	Agresta S. Coop.	Spain	Industrial	Company
571	Engineering Systems for the Defence of Spain, S.A - Ingeniería de Sistemas para la Defensa de España, S.A (ISDEFE)	Spain	Industrial	Private company
572	Entrearbres S.L.P.U.	Spain	Industrial	SME
573	FORESCAT, SL	Spain	Industrial	SME
574	Mitiga Solutions S.L.	Spain	Industrial	Private company
575	Federation of Forestry Associations of Baix Llobregat	Spain	Landowners / managers	Landowners (private)
576	Barcelona Provincial Council - Diputació de Barcelona, DiBa	Spain	Policy and regulation makers	Regional authorities
577	Castile and Leon Regional Government - Junta de Castilla y León	Spain	Policy and regulation makers	Regional authorities
578	Environment and Water Agency, Andalusian Regional Government - Agencia de Medio Ambiente y Agua, Junta de Andalucía	Spain	Policy and regulation makers	Regional authorities
579	Forest Fire Prevention Service - Servei de Prevencio d'Incendis Forestals. Government of Catalonia	Spain	Policy and regulation makers	Regional authorities

Copyright © FirEUrisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
580	Forest Property Center - Centre de la Propietat Forestal	Spain	Policy and regulation makers	Regional authorities
581	Meteorological Service of Catalonia - Servei Meteorològic de Catalunya, SMC	Spain	Policy and regulation makers	Regional agencies
582	Spanish Ministry for the Ecological Transition and the Demographic Challenge, MITECO. Área de Defensa contra Incendios Forestales	Spain	Policy and regulation makers	National authorities
583	Autonomous University of Barcelona, UAB	Spain	Scientific community	Academia
584	Forest Science and Technology Centre of Catalonia, CTFC	Spain	Scientific community	Research
585	Polytechnic University of Catalonia, UPC	Spain	Scientific community	Academia
586	Polytechnic University of Catalonia, UPC. Centre d'Estudis del Risc Tecnològic, Departament d'Enginyeria Química	Spain	Scientific community	Academia/Research
587	Science-based climate risk intelligence	Spain	Scientific community	Research
588	Spanish National Research Council, CSIC	Spain	Scientific community	Research
589	Spanish National Research Council, CSIC - Instituto de Ciencias Forestales, ICIFOR-INIA	Spain	Scientific community	Research
590	Spanish National Research Council, CSIC - Centro de Investigación Ecológica y Aplicaciones Forestales, CREAF	Spain	Scientific community	Research
591	Spanish National Research Council, CSIC - Centro de Investigaciones sobre Desertificación, CIDE	Spain	Scientific community	Research
592	Spanish National Research Council, CSIC - Institute of Environmental Assessment and Water, IDAEA	Spain	Scientific community	Research
593	University of Murcia	Spain	Scientific community	Academia
594	University of Zaragoza - Geoforest Research Group	Spain	Scientific community	Academia
595	Cartographic and Geological Institute of Catalonia, ICGC	Spain	Civil society orgs	Regional agencies
596	Hospital Universitario de Navarra, HUN	Spain	Hospital/medical	Hospital
597	COMPLUTIG	Spain	Industrial	Company
598	Tecnosylva	Spain	Industrial	Private company
599	Open University of Catalonia, UOC	Spain	Scientific community	Academia
600	Pablo de Olavide University, UPO	Spain	Scientific community	Academia
601	Spanish National Research Council, CSIC - Instituto de Ciencias Forestales, ICIFOR-INIA	Spain	Scientific community	Research
602	Spanish National Research Council, CSIC - Instituto Mixto de Investigación en Biodiversidad, IMIB	Spain	Scientific community	Research
603	University of Oviedo	Spain	Scientific community	Academia
604	University of Zaragoza	Spain	Scientific community	Academia
605	Swedish Civil Contingencies Agency, MSB	Sweden	Policy and regulation makers	National agencies
606	Fire vigilance of Kalmar County - Räddningstjänsten Sydost	Sweden	First responders	Firefighters
607	Forestry Research Institute of Sweden, Skogforsk	Sweden	Scientific community	Research
608	Lund University. Division of Risk Management and Societal Safety	Sweden	Scientific community	Research
609	Bassa Mesolcina Fire Department - Corpo Pompieri Bassa Mesolcina	Switzerland	First responders	Firefighters
610	Federal Institute of Technology Zurich, ETH Zurich	Switzerland	Scientific community	Research
611	Istanbul University-Cerrahpaşa	Turkey	Scientific community	Academia
612	İzmir Katip Çelebi University	Turkey	Scientific community	Academia

Copyright © FirEURisk Consortium. All rights reserved.

No.	Attendant Institution	Country	Stakeholder Category	Competences in Fire
613	Legal Response International, LRI	UK	Civil society orgs	NGO
614	Institute of Civil Protection and Emergency Management	UK	First responders	Civil Protection (National)
615	Urban Hawk Ltd	UK	Industrial	Private company
616	Venaka TReLeaf GbR (VTG)	UK	Industrial	SME
617	Coventry University - Research Centre for Business in Society	UK	Scientific community	Academia
618	Imperial College London	UK	Scientific community	Academia
619	The University of Edinburgh	UK	Scientific community	Academia
620	Chornobyl Radiation and Ecological Biosphere Reserve	Ukraine	Landowners / managers	Landowners (public)
621	The Nature Conservancy	USA	Civil society orgs	NGO
622	Western Fire Chiefs Association and Earth Fire Alliance	USA	Civil society orgs	NGO
623	Emergency Alerting & communications IP development	USA	First responders	National agencies
624	U.S. Ministery of Environment Waters and Forests	USA	Policy and regulation makers	National authorities
625	NASA/University of Maryland Baltimore Co.	USA	Scientific community	Academia
626	University of Maryland Baltimore Co.	USA	Scientific community	Research
627	National Councils for Sustainable Development – NCSD ncsrd	-	Policy and regulation makers	Intergovernmental Organization
628	UN Food and Agriculture Organization, FAO	-	Policy and regulation makers	Intergovernmental Organization
629	World Bank	-	Policy and regulation makers	Intergovernmental Organization

Copyright © FirEURisk Consortium. All rights reserved.

10. Annex B: FirEURisk Product Portfolio cross-reference table

FirEURisk Product Portfolio Cross-Reference Table

Integration across European, Regional and Local scales within the IWRM framework

IWRM Component	European Core Products	Regional Products	Local Products
Danger Assessment	Probability of Human Ignition (PHI)	Human ignition probability for PS	—
	Live Fuel Moisture Content (LFMC)	Live-fuel moisture content archive	—
	Fuel Classification Map (FCM)	Fuel type, fuel model, and metrics	Custom fuel characterization
	Propagation potential indicators	Propagation potential for PS	—
	—	Fire danger metric	Daily Fire Danger Index
	—	Smoke potential	Spring grass fire model
Exposure Analysis	Exposure (E)	Wildland-Urban Interface map	—
	—	Forest fire emission forecast	Health-impacts of wildfire-smoke
	—	Maps of fire exposure metrics	Eruptive fire risk map
Vulnerability Evaluation	Ecosystem services (ESva)	—	Potential Losses on ES
	Coping capacity & Recovery time	Persistence Index Map	—
	Houses value (HV)	Relative Societal Vulnerability Index	Suppression Difficulty Index
Risk Assessment	Integrated fire Risk Index (IRI)	—	—
Risk Mitigation	Maps of Suitability of LMS	Fuel Management Framework	—
	Guidelines for extreme fires	WUI guidelines	Guidelines for citizens
	Fire behaviour predictive models	Land Management Strategies	Building survivability factors
Risk Adaptation	Continental land-use scenarios	Future climate information	Fire risk predictions
	—	Future fire regime database	Adaptation to changed regimes
	—	High resolution climate for Greece	—
Instrumental Products	FirEURisk Open Viewer	Program of prescribed burnings	Citizens/scientist network
	Laws, regulations, plans	Forest condition biotic damages	Analysis of socio-economic barriers
	—	—	Guidelines for on-site surveys

Products in the same row are related across different spatial scales. "—" indicates no direct equivalent exists at that scale.

Copyright © FirEURisk Consortium. All rights reserved.