- Mayor of Toén (Ourense)
- Forestry technician for Forest District IX (Lugo-Sarria).
- Technician responsible for the Ourense forest area.
- Deputy Director General of the Galician Agency for Rural Development (AGADER).
- Representative of the Galician Regional Police on forest fire matters.
- Forestry technician for Forest District XII.
- Representative of the Directorate General for Forest Protection.

24.06.2023 WORKSHOP 2: AWARENESS AND TRAINING FOR VILLAGE RESIDENTS ON THE RURAL-FOREST INTERFACE AND THE POSSIBLE EXPOSURE OF TRELLE TO AN EXTREME FOREST FIRE

Introduction

In this second meeting, we delved deeper into the concepts of the rural-forest interface, community vulnerability and individual self-protection measures. We proposed specific risk scenarios for Trelle, based on its topography, urban planning and adjacent forest mass.

Objectives

Our main objectives were to raise awareness among the population about their real exposure to extreme forest fires and to identify critical points in the village: escape routes, safe areas and possible firebreaks. We also provided instruction on individual and collective self-protection measures.

Methodology

To this end, we held a workshop using local cartography, orthophotos and propagation models, worked on designing a neighbourhood emergency plan and carried out a simulation of a typical rapidly evolving forest fire scenario.

Figure 37: Simulation carried out by the UTA, tactical analysis unit.

At this point, we should highlight the implementation of Virtual Reality as an innovative training tool. Training through immersive experiences.

Figure 38: Image of an extreme forest fire created using virtual reality, targeting the safe model village of Trelle.

Conclusions

We saw first-hand that the village is highly vulnerable, mainly due to the abundance of plant fuel and the proximity of forests to homes.

We consider it essential to establish perimeter protection zones, improve the design of escape routes and correctly signpost confinement areas.

And very importantly, there is a clear need to include elderly people and those with reduced mobility in the system through a personalised assistance plan.

Figure 39: Left: Training for residents of the Trelle model safe village. Right: Training for residents of the Trelle model safe village.

Figure 40: Leaflet designed specifically for the Trelle model safe village

Figure 41: Protection tips for the safe model village of Trelle

Participants

- Forest firefighters assigned to the Directorate-General for Forest Protection (Galician team responsible for the Atlantic Living Lab FIRE RES)
- Residents of the village of Trelle (Toén, Ourense)

17 & 18.12.2024 WORKSHOP 3: EMERGENCY DRILL AND PRACTICAL EXERCISES

Introduction

This session was eminently practical and allowed participants to test the knowledge acquired during the previous workshops in a real-life setting. A comprehensive drill was carried out involving the entire community of Trelle and a large part of the Galician Forest Fire Prevention and Extinction Service (SPIF), with exercises in logistics, coordination and use of resources (land and air).

Objectives

The main objective was to assess the degree to which the population had assimilated the concepts.

To do this, it would be best to put the emergency plan into practice: evacuation, confinement, meeting points and training in the use of first response tools: hydrants and hose laying.

Methodology

We activated a standard drill with a fictitious fire alarm, which consisted of a timed evacuation and confinement exercise. We also included technical training with the support of SPIF personnel.

In one of the manoeuvres, we demonstrated and tested a state-of-the-art tool created by forest firefighters in Galicia, the double-action forest lance, the only forest lance in the world capable of effectively extinguishing fires while protecting the forest firefighter from the radiation of the flames by means of a water shield.

Conclusions

The community responded effectively, although shortcomings were detected in internal communication and coordination between scattered homes.

The role of 'neighbourhood leaders' as key figures in organising the immediate response was reinforced.

Basic technical training (watering, hoses) was well received, and future refresher sessions were requested.

Figure 42: Image of the drill carried out by the forest fire prevention and extinction service of the Regional Government of Galicia in Trelle.

Figure 43: Image of the drill carried out by the forest fire prevention and extinction service of the Regional Government of Galicia in Trelle.

Figure 44: Tests carried out with the double-action forest fire extinguishing nozzle. :

About these practical guidelines with the double-action forest fire lance, simultaneous extinguishing and protection. The only forest fire lance in the world capable of effectively extinguishing flames while protecting the forest firefighter from the dreaded radiation of the fire.

26 & 27.03.2025 WORKSHOP 4: PROPOSALS AND POSSIBLE SOLUTIONS FOR THE RURAL-FOREST INTERFACE

Introduction:

The programme concluded with a technical meeting with national experts in forest management, land-use planning, fire protection and resilient landscapes. Innovative proposals that can be adapted to rural contexts such as Trelle were presented.

Objectives

Of course, to propose medium- and long-term structural solutions to reduce risk.

It will be very important to identify collaborative strategies between the administration, the community and the forestry sector.

And finally, to reinforce the role of education and continuous training in fire culture.

Methodology

For this last workshop, we used the model of keynote lectures by top-level experts and technicians.

Conclusions

Villages must definitely be integrated into local civil protection systems, with their own resources and continuous training. Strategic land use planning is essential, with criteria of discontinuity and multifunctionality of the territory.

We are convinced that the village of Trelle can become a replicable benchmark for other rural areas in the north-west of the peninsula.

Figure 45: Team of speakers at workshop 4 on the Estrada

Figure 46: Image from the Symposium on Extreme Forest Fires.

Figure 47: Image from the Symposium on Extreme Forest Fires.

Figure 48: Image from the Symposium on Extreme Forest Fires.

Figure 49: Image from the Symposium on Extreme Forest Fires.

Participants

- Sergio Pironne (director of the school for gifted children in Piedmont, Italy)
- David Caballero (forestry engineer)
- Staff from all professional categories of the SPIF (Galicia)

- Director General of Forest Defence, Regional Ministry of Rural Affairs

Final conclusions

The pilot project carried out in Trelle shows that community involvement and ongoing technical training are two key things for dealing with the new threat of extreme forest fires. Change needs to be structural, but also deeply cultural: we need a new kind of fire literacy, adapted to the 21st century.

The combination of technical diagnosis, community participation, real-world practices and the transfer of specialised knowledge has set a valuable precedent that deserves to be replicated, expanded and systematised. Strategic recommendations:

We would like to conclude this work by adding some STRATEGIC RECOMMENDATIONS that we consider vital to the success of this initiative:

On the one hand, it would be essential to incorporate annual continuing education to maintain and update the knowledge acquired.

On the other hand, it is very important to create a local emergency response protocol validated by civil protection.

Of course, the village must be equipped with sustainable and maintainable first response resources (fire extinguisher backpacks, water points, etc.). Cultural and physical firebreaks must be established at the forest interface.

And most importantly, public policies must be promoted to support the agroforestry mosaic as a natural barrier against fire.

8.4.2. The IA demonstration results at LL level

IA1.3 Early-warning indicators of EWEs

Accurate and timely warnings are essential to prevent and mitigate the impacts of EWE. In IA1.3 we used advanced probabilistic modelling to forecast the daily occurrence of EWEs at an 8 km resolution across Europe up to 9 days in advance. Our model significantly improved the current estimation of EWE probability while providing key insights into the environmental and climatic drivers of EWEs. Compared to the Fire Weather Index (FWI), our model increased precision by a factor 5 for EWE predictions at the NUTS3 level and by a factor of 10 at 8km resolution. To assess further assess it operational relevance, we evaluated the model's forecasting skill in a test area. Our results demonstrate that EWE forecasts up to nine days in advance outperformed FWI- based nowcasts, emphasizing the model's potential for operational use and its superiority in anticipating EWEs compared to current fire danger rating systems

IA3.3 Parametric solutions for insurance products

A parametric fire insurance scheme, developed as part of Innovation Action 3.3: Parametric Solutions for Insurance Products, has been tested in Living Lab Galicia. This innovative methodology utilizes a trigger-based system, integrating a fire propagation model with satellite observations to enhance accuracy. Additionally, it incorporates a calculation agent to estimate economic losses within the forestry sector, ensuring a robust and automated assessment process.

Designed specifically for large-scale and long-duration wildfires, the system continuously monitors fire progression through numerical modelling and remote sensing data, enabling real-time risk evaluation. To validate its effectiveness, the scheme was applied to two of the most severe wildfires recorded in Galicia in recent decades. Simulations assessed trigger activation across different forest assets, demonstrating the correlation between model outputs and actual damages. These findings highlight the methodology's potential as a reliable tool for parametric insurance products, offering rapid payouts based on predefined fire behaviour thresholds.

The development and testing process is documented in Deliverables 3.5, 3.6, 3.7, and 3.8. By leveraging advanced modelling and satellite technology, this solution addresses critical gaps in traditional insurance mechanisms, particularly in regions prone to catastrophic wildfires.

IA4.4 Fire-safe villages

IA4.4 aimed to transform the village of Trelle into a model of safety against extreme forest fires through a multi-pronged strategy. Key actions included reducing vegetation fuel around the village, enhancing critical infrastructure like firebreaks and water points, and developing a Virtual Reality simulation to raise awareness. Training sessions, drills, and educational materials were provided to the local population, alongside the creation of a novel firefighting tool—a double-action nozzle that both extinguishes flames and shields firefighters from heat.

Four annual workshops supported the initiative. The first explored the structural causes of extreme fires in rural Galicia and introduced the concept of a "model safe village." The second focused on community vulnerability and self-protection, using simulations and VR to train residents. The third was a hands-on emergency drill involving the entire village and fire services, testing evacuation plans and showcasing the new nozzle. The final workshop gathered national experts to propose long-term solutions, emphasizing strategic land-use planning, continuous education, and community integration into civil protection systems.

Overall, the project highlighted the importance of proactive land management, community engagement, and innovative tools in building resilience against forest fires, positioning Trelle as a replicable model for other rural areas.

IA5.1 Integrative umbrella system for estimating EWE risk and impact

The ISS application's main page highlights different LLs, including the Galician LL. The user can access the implemented solutions and services for the LL. These include:

- Integration of the CSIC exposure sensors application (IA 5.7) that displays and allows to download the exposure data from sensors in Galicia.
- A pyroconvective simulation system (IA 5.2) from CNRS that includes two simulation tools, i) FOREFIRE wildfire surface spread model and ii) Meso-NH. FOREFIRE addresses the simulation of the fire and smoke behaviour of fires with high potential of EWE. It runs in the LL and has been tested on real wildfire scenarios in the LL in collaboration with the operational fire services from the LL.
- Technosylva analysed external services, considering outcomes from WP1, and integrated a set of EUMETSAT and Copernicus services into the ISS to provide users with EWE conditions forecasts.
- Weather layers from the SPIRE weather forecast (IA 5.5) from the Basic, Upper-Air and Thunderstorm bundles.

IA5.6 High Altitude Pseudo Satellites

In the HAPS simulation, Galicia maintains a consistent deployment of one HAPS throughout the entire May to September period. In addition, there were up to 2 HAPS at Pan-European level to cover the peaks in the Southern Living Labs. While this setup generally performs well in monitoring over 99% of the burnt area and keeping arrival at 2 hours and 13 min as average. In July, the average burnt area of fires that could not be monitored reached 111 hectares, being below 100ha the rest of the months.

IA5.10 Pan-European system to define management priorities

The innovation action “Pan-European System to Define Management Priorities for Mitigating Fire Impact” aimed to design a prototype system for identifying strategic fuel management priorities based on multiple criteria.

To develop this system, we began by defining a set of relevant criteria and assessing the need to model and map these variables. Among the most critical variables were fuel accumulation and potential fire behaviour, which, at the start of the project, were not adequately covered by existing information. During the initial years, the University of Padova mapped all fuel-related variables necessary to estimate fuel accumulation and simulate fire behaviour. This effort resulted in four scientific articles and the development of a server where the information is publicly available for download (https://www.cirgeo.unipd.it/fire-res/app/). Technosylva used this data to simulate high-intensity fire behaviour across the EU. Simultaneously, ISCI developed a multi-criteria decision support system calibrated to the generated data. This system can assign priority scores once the data is harmonized, and criteria are weighted accordingly. Currently, a strategic prioritization exercise is underway for the Iberian Peninsula, demonstrating the supranational capacity of this analysis and illustrating how large-scale, policy-oriented frameworks are most suited for this system. After the Iberian exercise is completed, the multi-criteria system, programmed as a QGIS plugin, will be publicly available.

Looking ahead, we plan to develop a dedicated server where users can easily download relevant data for such analyses. This platform will also store new data, especially concerning values and risk assessments, alongside existing datasets.

8.4.3. Next steps until 2030

The **required actions/activities** to move from the status-quo towards the desired vision – according to the CWI are:

- Indicate if some of the previously identified challenges are already tackled by FIRE-RES Innovation Actions.
- Indicate how potential interdependencies are considered, this is, if some of the activities require sequential approach (A needs to be solved first, then B can be addressed).
- Illustrate the roadmap with a graph

The current Forest Fire Prevention and Extinction Service SPIF is a very powerful service. It has some of the best technology and machinery in the country. Two of its strong assets or advantages are the dispersion on the territory and the knowledge of the terrain. Nevertheless, there are issues to be improved to be able to face the new EWE:

- Training and drills with the local population of the villages (IA 4.4 Fire-safe villages)
- Training of the firemen on the watchtowers 3.0 (IA 4.4 Fire-safe villages)
- Development of innovative tools that are efficient and life protecting during the forest fires fighting (water lances and luminescent hoses)
- Development and application in buildings in fire-risk areas of innovative protective materials that are fire-resistant
- Implementation of the law on land restoration, establishment of more model villages and agroforestry polygons
- Simplification of the bureaucracy for the landowners

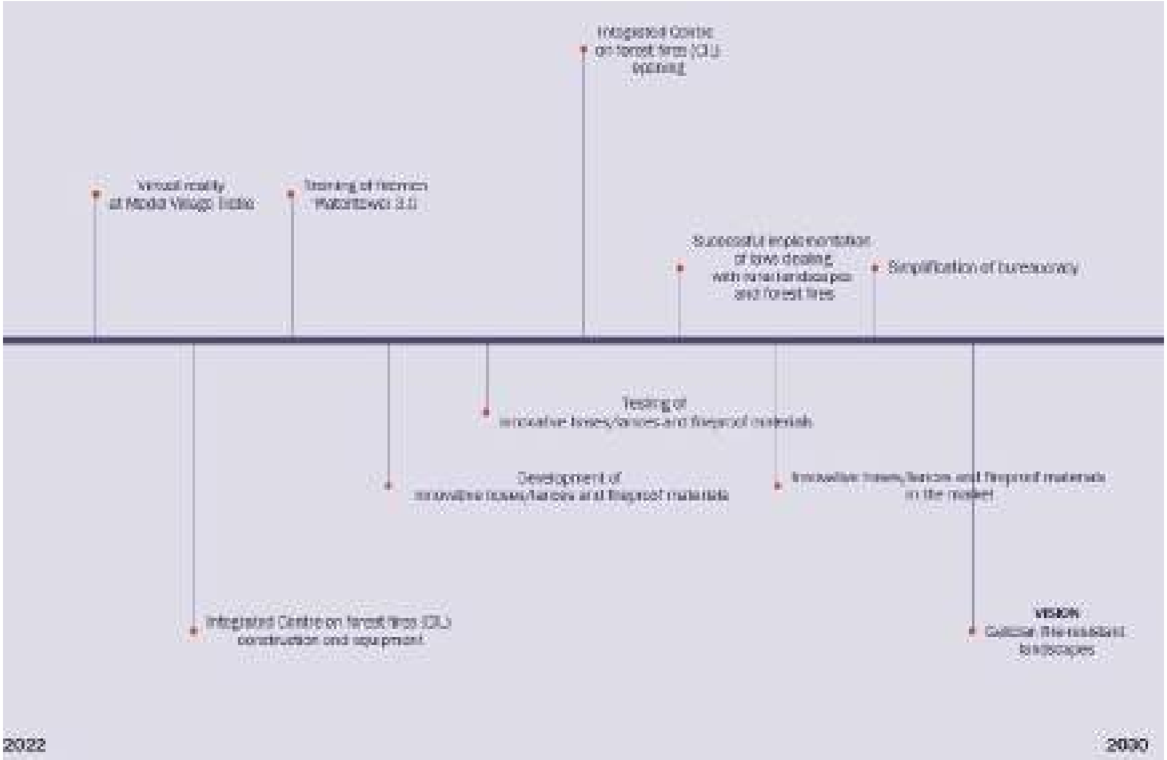

Figure 50: Roadmap for the Living Lab Galicia.

8.5. CWI feedback

The CWI participants indicated that the time for discussion was short, but they showed interest in being part of the discussion and they would like to join future meetings. They considered that the stakeholders' representation could be expanded to include the scientific community and more inhabitants or companies from the area. It is of interest for them to learn about good practices implemented across Europe, that could be replicated in the region.

8.6. References

Law 3/2007 on prevention and defence against forest fires in Galicia [Ley 3/2007, de 9 de abril, de prevención y defensa contra los incendios forestales de Galicia. (boe.es)]

Law 7/2012 on Galician forests [Lei do DOG nº 140 do 2012/7/23 - Xunta de Galicia]

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Review of the Forest Plan in Galicia. Towards carbon neutrality [20211112-plan-forestal-galicia-2021-2040-cast.pdf (xunta.gal)]

Annual Plan on forest fires. PLADIGA https://mediorural.xunta.gal/es/temas/defensa-monte/pladiga-2022

Daily Index on fire risk. IRDI https://mediorural.xunta.gal/es/temas/defensa-monte/irdi

9. Germany-The Netherlands (GER-NL)

Authors: Cathelijne Stoof, Jasper de Vries, Julissa Galarza

9.1. Wildfire context

9.1.1. Fire regime, socio-ecological context, and impacts

Despite the fact that wildfires tend to be associated with Mediterranean countries, wildfires in The Netherlands and Germany actually also have a long history, with wildfire disasters for instance occurring in 1917 (Valthermond, NL) and in 1975 (Lüneburger Heide, Germany). Despite this, wildfire statistics are not systematically collected – The Netherlands stopped its dedicated wildfire statistics collection in 1994 and only started again in 2017, albeit not mandated by law. Stoof et al (2024) recently published the new wildfire statistics for the period 2017-2022, reporting an average of 611 wildfires and 405 ha burned per year. They count all fires regardless of vegetation type. Fires mostly occurred in spring, and during summer drought. Heathlands burn more than forests, average size was 1.5 ha, are typically caused by people, and often burn simultaneously (Stoof et al, 2024). Germany records wildfire statistics by province (*Land*) and focuses only on fires in forest. The German Federal Agency for Agriculture and Food reported between 450 and 3000 forest fires per year with a total of 100 to 5000 ha area burned, at an average size of 0.2 to 1.8 ha per fire (San Miguel Ayanz et al, 2024). Note that the Copernicus' European Forest Fire Information System (EFFIS) underestimates wildfire occurrence and burned area in this region because of the relatively small side of wildfires (Stoof et al, 2024). Wildfire danger has been increasing in temperate Europe during the last decades and is expected to further increase with climate change (Lambrechts et al, 2024; Stoof et al, 2024; Perry et al, 2022).

In terms of impacts, official recordkeeping is absent. For The Netherlands, Stoof et al. (2024) however created an overview of socio-economic impacts of wildfires based on unpublished data from fire services and media reports. The authors illustrate that also small fires can have significant consequences: in The Netherlands the effects of wildfire already include blockages of highways, railways and ship traffic, evacuations of thousands of people, smoke impacts, burned homes, traffic accidents and fatalities, amidst grave concern for fire fighter safety. Evacuations have included campgrounds, villages, elderly homes, national park Hoge Veluwe and the Kröller Moller museum, a juvenile prison and a homeless shelter (Stoof et al, 2024).

9.1.2. Wildfire governance

Despite the existence of wildfires and their already significant impact, wildfire governance is in its infancy. In The Netherlands, the last specific wildfire-related policy was abolished in 2002 (Stoof et al. 2024), and there are currently no laws and policy directly focused on fire management. During the last four years, major progress has however been made in putting wildfires on the political agenda in The Netherlands, which our team has been part of.

Figure 51: Minister Christianne van der Wal (The Netherlands) visiting the Catalan Living Lab in June 2023 with the Dutch fire service.

In 2023, the Dutch Minister Van der Wal (Ministry of Agriculture, Food, Fisheries and Nature) visited Catalonia and the Catalan Living Lab with the Dutch fire service – part of our CWI. The visit was a combination of a field trip and presentations, during which our team addressed the Minister about the need to address integrated fire management in The Netherlands with urgency. After this visit, Minister Van der Wal announced the intention to invest 70 million euros and a national centre of expertise. In 2024, her ministry officially recognized wildfires as their responsibility, after the topic was not officially part of any ministry's jurisdiction. Additionally, the Dutch government recognized fire as a natural process that needs to be lived with, like we do with water:

"It is important to realize that it is not possible to prevent or suppress all wildfires. There should be some degree of risk acceptance. Just like water, fire is part of nature. Fully excluding fire can have unintended consequences and is practically not feasible. Similar to the concept of 'Room for the River' the goal is to let fire be part of the landscape in a manageable way' (Rummenie, 2024).

The three pillars of integrated fire management that the Dutch government has identified are risk management, crisis management and knowledge and innovation, aiming for on a resilient society. In the absence of laws on landscape fires, a **national covenant** is in development to clarify roles and responsibilities across the disaster management cycle, including the development of local fire management plans. A **national crisis plan** covers wildfire suppression agreements, and a new **National Centre for Wildfires** will aim to develop knowledge and education, all focused on landscape fires.

Within the Living Lab Germany-The Netherlands, we have supported this process in four key ways: 1) providing the science, 2) advocating for putting wildfire on the political agenda, through science communication and direct engagement, and 3) bringing the stakeholders together in formal and informal settings to connect science, practice and policy, and identify ways forward together.

9.2. Vision for wildfire-resilient landscapes in 2030

9.2.1. A 2030 wildfire-resilient landscape in Germany and the Netherlands.

The Germany Netherlands Living Lab adopted Newman Thacker et al.'s definition of a fire resilient landscape as "a socio-ecological system that accepts the presence of fire, whilst preventing significant losses through landscape management, community engagement and effective recovery" (Newman Thacker et al, 2023). Their framework focuses on five key components:

- Acceptance and use of fire: fire as a natural process, prescribed burning,
- Landscape management: mosaic landscape, fuel management,
- Community engagement: knowledge sharing, collaboration, education; trust; prevention,
- Loss avoidance: absence of long-lasting damage, trained suppression force,
- Recovery: return to stable state, fire resilient species.

Newman Thacker et al (2023) highlight the military site ASK 't Harde in The Netherlands as a fire resilient landscape, describing the integrated and collaborative practices taking place at this member of our Community of Wildfire Innovation. This case illustrates that good examples exist in the region, which can serve as inspiration to the wider Community of Wildfire Innovation in the Living Lab.

Figure 52: Key components of a fire resilient landscape (Newman Thacker et al, 2023).

9.2.2. Resilience in wildfire management

Notwithstanding efforts made in recent years, key challenges to reaching resilient wildfire management are rooted in two main causes: first, the lack of community awareness of the risk of wildfires and the therewith lack of political and policy attention over the past decades. Second, the fragmentation of policy and management among a wide range of stakeholders and responsible authorities. This is even stronger manifested in cross border and cross boundary regions.

A vision for resilient wildfire management therefore centres around the following aspects:

- Acceptance and use of fire: fire as a natural process, prescribed burning: fire is accepted as a natural part of landscape management and in the understanding of functional ecosystems. Policies and legal requirements are supporting this perspective. The use of fire is accepted and used as management strategy and natural process in relevant ecosystems, habitats and landscapes.
- Landscape management: mosaic landscape, fuel management,
- Community engagement: knowledge sharing, collaboration, education; trust; prevention

9.2.3. Resilience in post-fire management and adaptation

Resilience in post-fire recovery now focusses largely on recovery of ecological processes, effective measures and collaboration. In terms of post-fire management and adaptation for Germany and the Netherlands, the debate on new, climate resilient species in forests is taking shape in both countries. The main challenge here is the long-term adjustment to climate change, as the new climate reality requires critical thinking of species, landscapes and land uses used in recovery. It also requires critical thinking about which state should be bounced back to: is recovery to previous states a realistic and optimal solution in a landscape that is changing?

9.2.4. Other resilience gaps

See gaps to reach the vision.

9.3. Gaps to reach that vision

Our first annual Community of Wildfire Innovation meeting in 2022, participants discussed the main challenges for better preparing The Netherlands for wildfires. The key gaps identified were:

- communication,
- a common vision,
- awareness,
- partner roles and tasks,
- education,
- an integrated approach, and
- a normative framework to complement existing policy

As discussed in Section 9.1 and 9.2, since this initial CWI meeting major progress has taken place in terms of wildfire governance, meaning that all these points have been or are currently being addressed. However, backwards progress has been made in terms of the acceptance of fire in the landscape. While the government highlights acceptance of fire as a key aspect of integrated fire management (Section 9.1), soon after the possibility to do small-scale prescribed burns was removed from the code of conduct of nature managers (Gedragscode Natuurbeheer). This illustrates that, despite the major developments in wildfire governance, there is still a long way to go.

9.4. Steps and milestones: the roadmap

9.4.1. Progress achieved during the project (at CWI level)

In response to limited fire governance and related knowledge, Germany / the Netherlands Living Lab established its Community of Wildfire Innovation (CWI) at the national level. We tailored our approach to the needs of the Living Lab and to where the potential and political opportunity was highest. As mentioned in section 9.1 we supported the development of wildfire governance in our Living Lab by providing the science, advocating for politically addressing wildfire risks, and bringing stakeholders together in formal and informal settings to connect science, practice and policy, with annual meetings to tackle these challenges. Two key milestones are the development of the new wildfire statistics for The Netherlands (Stoof et al, 2024), after official recordkeeping was halted in 1994, and the inclusion of a new "acceptable risk" section in Dutch fire management plans—marking the first time such discussions are being formally encouraged among stakeholders. The Living Lab additionally brought German and Dutch stakeholders together with experts from Southern Europe, for an integrated fire management training that was organized in Germany in 2023 and later replicated in Lousã, Portugal. Through our science, engagement and networking our team played and plays a key role in developing wildfire governance, knowledge and expertise in The Netherlands, with potential impacts extending into the broader temperate region.

Figure 53: Integrated living with fire training, Walsrode, Germany, 9-13 Oct 2023.

The annual meetings of our Community of Wildfire Innovation began with 30 specialists in the first year (2022) and has grown significantly, with the latest edition—co-organized by the Dutch province of Noord-Brabant, the forest service and the fire service— bringing together 250 participants. These gatherings also served as a platform to assess the needs of the fire management community, with insights feeding directly into policy clinics.

2022 National stakeholder day wildfires in The Netherlands

Time/place: 4 Jul 2022, Wageningen, The Netherlands

Objective: To exchange knowledge on fire management and co-create an agenda for an integrated fire management approach for The Netherlands.

Attendees: 35 people, decision makers and experts in wildfire representing ~20 organizations including national, regional and local governments, Staatsbosbeheer, VBNE, Probos, Bosgroep, NIPV, safety regions, and the meteorological institute KNMI.

Outcome: Ina Adema, governor of the Province of Noord-Brabant opened the day, she and Marc Castellnou (Catalan Fire & Rescue Service), Jelmer Dam (Dutch fire service) and Cathelijne Stoof (Wageningen University, Living Lab coordinator) discussed current challenges and developments in fire management. In the afternoon, interactive discussions focused on challenges now and in the future as well as current needs and how those can be addressed. Key gaps identified that need to be addressed to better prepare The Netherlands for wildfires are communication, a common vision, awareness, partner roles and tasks, education, an integrated approach, and a normative framework to complement existing policy.

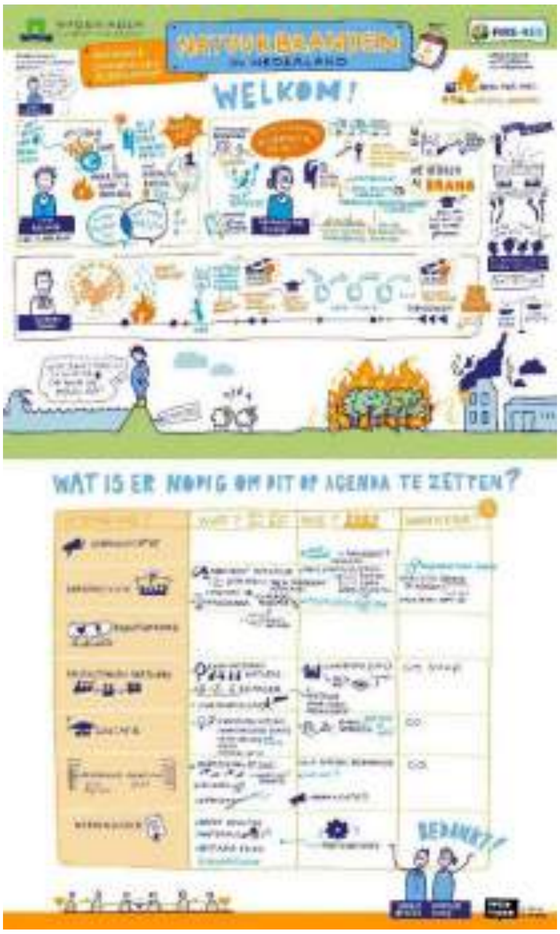

Figure 54: Summary of pitches and discussion outcome of 2022 National Stakeholderday Wildfires in The Netherlands

2023: The State of Wildfires in The Netherlands 2023

Time/place: 27 Nov 2023, Wageningen, The Netherlands.

Objectives: 1) to bring together diverse professionals active or interested in wildfires in The Netherlands; 2) provide insight into current developments the past fire season, from global to local scale, in science and in practice; and 3) learn together from good

Figure 55: The State of Wildfires in The Netherlands 2023

practices and fantastic failures through interactive discussions about collaborations, management, communication and history.

Attendees: 70 people, representing 38 organizations including national, regional and local governments, Staatsbosbeheer, VBNE, Probos, Bosgroep, NIPV, safety regions, insurance sector, Department of Defence, Central Government Real Estate Agency, Highway Authorities, meteorological institute KNMI and academia, as well as several Belgian organizations.

Outcome: Presentations from academia, practice and policy informed the audience of current developments in fire in The Netherlands (Cathelijne Stoof), globally (Guido van der Werf), and in Europe (Marc Castellnou), after which developments were shared from the Dutch forest service (Marc Brosschot, Tiemen Brouwer), fire service (Jelmer Dam), as well as policy at national level (Pepijn Tersmette), provincial level (Robby Brekelmans) and local level (Amy Goossens, Sander Scholten). Land manager Brand Timmer and fire chief Eric van der Ouw jointly shared best practices and fantastic failures in integrated fire management at the military base ASK that they manage in close collaboration. Afternoon discussions focused on key developments around communicating wildfire danger, landscape management, wildfire awareness education through the serious game Play with Fire. Collaboration with AGIF (Portugal) and the European University Cyprus (through the EU project SEMEDFIRE) facilitated discussions of international perspectives around the Landscape Fire Governance Framework and about fire management on the divided island of Cyprus.

2024 The State of Wildfires in The Netherlands: samen voorwaarts (forward together)

Time/place: 20 Nov 2024, Provinciehuis 's Hertogenbosch, The Netherlands. After we coordinated the previous annual stakeholder days from our capacity as Living Lab Coordinator and Knowledge Hub for Integrated Fire Management from Wageningen University, we reached out to key stakeholders to co-organize this year's event together. Hence, the 2024 event was organized by our team, jointly with the fire service and forest service, and hosted by the Province.

Figure 56: The State of Wildfires in The Netherlands 2024: forward together

Objective: to inform a wide diversity of stakeholders about key developments in wildfire governance in The Netherlands (national covenant, centre of expertise); discuss challenges and solutions; consult our stakeholders for the FIRE-RES policy clinics; and provide opportunities for informal networking and learning.

Attendees: ~250 people from a range of organizations, including national, regional and local governments, Staatsbosbeheer, VBNE, Probos, Bosgroep, NIPV, safety regions, insurance sector, Department of Defence, Central Government Real Estate Agency, Highway Authorities, meteorological institute KNMI and academia, water boards and crisis experts; 10-15 Belgian experts representing governments, land management and emergency management also attended.

Outcome: The day was opened by the governor of the Province of Noord-Brabant, Ina Adema, who has been leading major changes in wildfire governance in her Province which are an example for the rest of the country. Invited presentations informed the audience of major developments in wildfire governance, land management, emergency management and science. Keynotes addressed how land management goals and fire prevention goals can go hand in hand (Henk Siebel), progressive hose lay as smart suppression (Robin Breeuwer), and climate risks, transitions and the broader policy context (Frank van Gaalen). Interactive afternoon sessions focused on practical aspects of fire prevention in landscapes, education and training, WKR initiative Swarm fire intelligence, opportunities and challenges in wildfire governance (FIRE-RES policy clinic), visioning an ideal future for fire management, what to do during a wildfire – for land managers, extreme fire behaviour, evaluating fire incidents, and dilemmas in operational decision-making. Interest in this event was such that it exceeded the capacity of the venue, and several organizations have indicated their interest to host the event next year.

2025: in progress

The 2025 annual stakeholder day is planned for 18 November and preparations are underway. The day will be focused on informing the diversity of attendees about the key developments in terms of integrated fire management, in policy, practice and science. The afternoon includes a panel and interactive group discussions on involving the public and increasing public participation in prevention of wildfire impacts, giving a podium to the residents at Landgoed Kamersven and journalist Christel Don who works on climate resilience. Together with the organizing stakeholders our intention is to continue to organize these annual events, possibly under the umbrella of the national center for wildfires.

9.4.2. The IA demonstration results at LL level

IA1.3 Early-warning indicators of EWEs

Accurate and timely warnings are essential to prevent and mitigate the impacts of EWE. In IA1.3 we used advanced probabilistic modelling to forecast the daily occurrence of EWEs at an 8 km resolution across Europe up to 9 days in advance. Our model significantly improved the current estimation of EWE probability while providing key insights into the environmental and climatic drivers of EWEs. Compared to the Fire Weather Index (FWI), our model increased precision by a factor 5 for EWE predictions at the NUTS3 level and by a factor of 10 at 8km resolution. To assess further assess it operational relevance, we evaluated the model's forecasting skill in a test area. Our results demonstrate that EWE forecasts up to nine days in advance outperformed FWI- based nowcasts, emphasizing the model's potential for operational use and its superiority in anticipating EWEs compared to current fire danger rating systems

IA1.4 Integrated fire management model

In Germany, a pilot training titled 'Integrated Living with Wildfires' was implemented in 2023. Organized by Wageningen University and Waldbrandteam in collaboration with CFRS, the training sought to equip professionals from diverse fields—such as land management, emergency response, and policy—with examples of tools and mindset to build wildfire-resilient landscapes. The event included a preliminary online session followed by an intensive in-person workshop in Walsrode. It emphasized interdisciplinary collaboration and was tailored for individuals capable of initiating change in their regions.

The Netherlands' activities in the Germany-Netherlands Living Lab were cantered on promoting societal awareness.

IA5.1 Integrative umbrella system for estimating EWE risk and impact

The ISS application's main page highlights different LLs, including Germany-Netherlands LL. By clicking on this area, you access the implemented solutions and services for the LL. These include:

- EUMETSAT and Copernicus services into the ISS to provide users with EWE conditions forecasts.
- Weather layers from the SPIRE weather forecast (IA 5.5) from the Basic, Upper-Air and Thunderstorm bundles.
- Daily wildfire risk simulation solution (FireRisk) and an operational wildfire simulator adapted to EWE conditions (FireSim) in the approach of IA 5.2. The first, it provides a daily risk assessment forecast for each 3 hours, for a total of 96h of risk.
- Daily creation of high-resolution weather data solution for the LL, a 96h high-resolution weather forecast (1-2 km spatial resolution) for 45 variables.

IA5.2 Real-time EWE simulation and smoke spread

The ISS integrates a daily wildfire risk simulation solution and an operational wildfire simulator adapted to EWE conditions, both implemented by TSYLVA. The first provides a daily risk assessment forecast for each 3 hours, for a total of 96h of risk forecast. The operational simulator FireSim features two main simulation modes, a fire propagation mode and a probabilistic simulation mode. The solution includes an EWE adjustment factor which is based on the inclusion of the Lifted Index weather variable provided by SPIRE's weather forecast service.

Both solutions make use of base data such as vegetation fuel maps, boundary maps, population and buildings data, among other, that has been shared by the LL. Furthermore, it makes use of high-resolution weather forecast data that is created daily for the LL, a 96h high-resolution weather forecast (1-2 km spatial resolution) for 45 variables.

9.4.3. Next steps until 2030

The key next steps that will be developed in our Living Lab are to contribute to the development of wildfire governance, knowledge and expertise, including Dutch laws and regulations and the national centre for wildfires. There is strong belief that collaboration between agencies, disciplines, and with neighbouring countries is the way forward, in education, prevention as well as smart suppression. With the vast expertise on wildfires internationally there is major potential to learn from other regions and not have to reinvent the wheel. A recently started analysis of what emerging fire regions can learn from others is expected to provide a key agenda for the Germany/Netherlands Living Lab as well as other emerging fire regions. As such, the knowledge, expertise and networks created in this Living Lab are expected to impact science, policy and practice far beyond the lifetime of this project.

Year	Milestones and objectives
2025-2026	To come to better wildfire, knowledge and expertise, the first one/two years after FIRE-RES will focus on supporting the development of the national centre for wildfires by providing knowledge and input (e.g. see IA1.3) and organizing national stakeholder days (milestone 1).
2027-2028	Objective for the second two years is contributing to further knowledge sharing and exchange through national stakeholder day 2 (milestone 2), and the objective is further the policy integration by seeking funding for a transdisciplinary project focussing on the gaps identified in 9.3.
2028-2030	The last two years focus on consolidating and further expertise development on the gaps identified in this document.

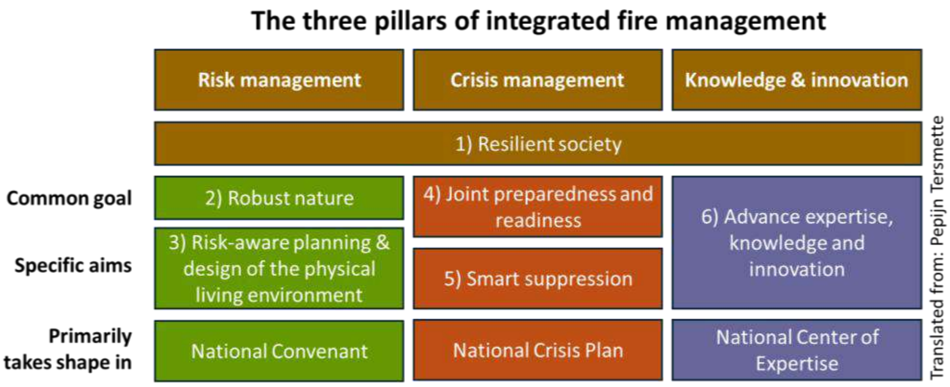

Figure 57: The three pillars of integrated fire management adopted by the Dutch government.

9.5. CWI description and involvement

The Germany/Netherlands CWI brought together local fire services, landowners, stakeholders from the insurance and tourism sectors, as well as representatives from both provincial and national governments, including the Defence department.

Table 13: Germany/Netherlands Community of Wildfire Innovation

Organization	Four-helix innovation system category	Geographic scale	Website
Ministry of Agriculture, Fisheries, Food security and Nature	Public sector	National	www.rijksoverheid.nl
Ministry of Safety and Justice	Public sector	National	www.rijksoverheid.nl
Provincie Noord-Brabant, kabinet CdK	Public sector	Regional	www.brabant.nl
Provincie Overijssel	Public sector	Regional	www.overijssel.nl
Provincie Limburg	Public sector	Regional	www.limburg.nl
Municipality of Breda	Public sector	Local	www.breda.nl
Municipality of Roerdalen	Public sector	Local	www.roerdalen.nl
Vereniging van Bos- en Natuurterreineigenaren	Private sector	National	www.vbne.nl
Staatsbosbeheer	Public sector	National	www.staatsbosbeheer.nl
Bosgroepen	Private sector	Regional	https://bosgroepen.nl/
Stichting Probos	Private sector	National	www.probos.nl
Fire service (multiple Safety Regions)	Public sector	Regional	www.brandweer.nl
Nederlands Instituut Publieke Veiligheid (NIPV)	Public sector	National	www.nipv.nl
KNMI - meteorological institute	Public sector	National	www.knmi.nl
Onderzoeksraad voor Veiligheid	Public sector	National	www.onderzoeksraad.nl
Wageningen University	Academy/Science	National	www.wur.nl

9.6. References

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10. Greece (GR)

Authors: K. Kalabokidis, O. Roussou, C. Vasilakos, P. Palaiologou

10.1. Wildfire context

10.1.1. Fire regime, socio-ecological context, and impacts

Experience in wildfires - Fire regime[9] and resilience axes[10]:

In Greece wildfires occur across a variety of vegetation types, with Mediterranean evergreen shrublands being the most frequently affected. These shrublands cover over 20% of the country and are especially common in coastal regions such as the Aegean islands, Crete, Peloponnesus, and central Macedonia. Fires here usually propagate along the surface under mild conditions but can intensify and spread rapidly under extreme weather. Pastures and grasslands, covering about 13% of the land—mainly in the Aegean islands and Crete—also experience fast-moving but lower-intensity fires. Low-elevation conifer forests, primarily *Pinus brutia* in the east and *Pinus halepensis* on the mainland, are highly flammable and prone to the most destructive wildfires, especially in WUI areas where human settlements increase the risk of property loss and casualties. These forests, which cover about 5% of the country, are vulnerable to crown fires due to the accumulation of dead needles, dense shrubs, and low canopy heights. Oak forests, covering 12% of Greece, usually burn in surface fires with low intensity, except in stands with dense shrub understory or when mixed with conifers, where fire intensity increases. High-elevation conifers, occupying 6% of the country above 800 meters, generally experience slow-moving fires of low to moderate intensity, though climate change has contributed to rare but severe stand-replacing events. Lastly, broadleaf forests, 3% of the landscape, are typically subject to low-intensity surface fires but can burn intensely when combined with conifers and exposed to drought and strong winds (Kalabokidis *et al.*, 2024).

The problem of forest fires in Greece is intensified when extreme events occur, as they cannot be suppressed immediately due to widespread WUI and the lack of forest management during climate change. Apart from the high and increasing risk of forest fires, many deaths from wildfires in residential areas in Greece has shown that the problem cannot be solved by suppression alone.

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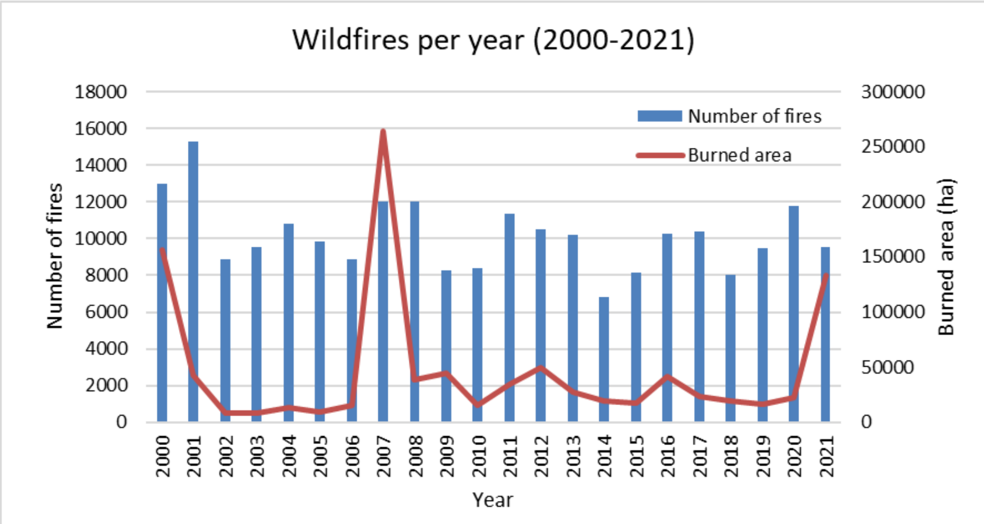
[9] A fire regime is the pattern, frequency, and intensity of the bushfires and wildfires that prevail in an area over long periods of time.

[10] McWethy et al. (2019) suggest basic, adaptive and transformative-resilience goals based on social–ecological context: axis a) human exposure & vulnerability to wildfire, axis b) fire severity, and axis c) fire novelty.

In the period 2000-2021, 223,261 forest fire events have been recorded by the Fire Service and resulted in 1,021,231 ha of area burned. The top panel of Figure 58 shows the annual distribution of fire events and the resulting burned area while the bottom panel reveals the monthly distribution. The typical duration of fire season is between June to October. In the period 2000-2021, 99.4% of small to medium-sized (<500 ha) wildfires burned 220,862 ha (21.6% of the total burned area), whereas only 0.6% of large wildfires (>500 ha) burned 800,369 ha (78.4% of the total burned area). The return period is 5-7 years, especially for large wildfires (Figure 59).



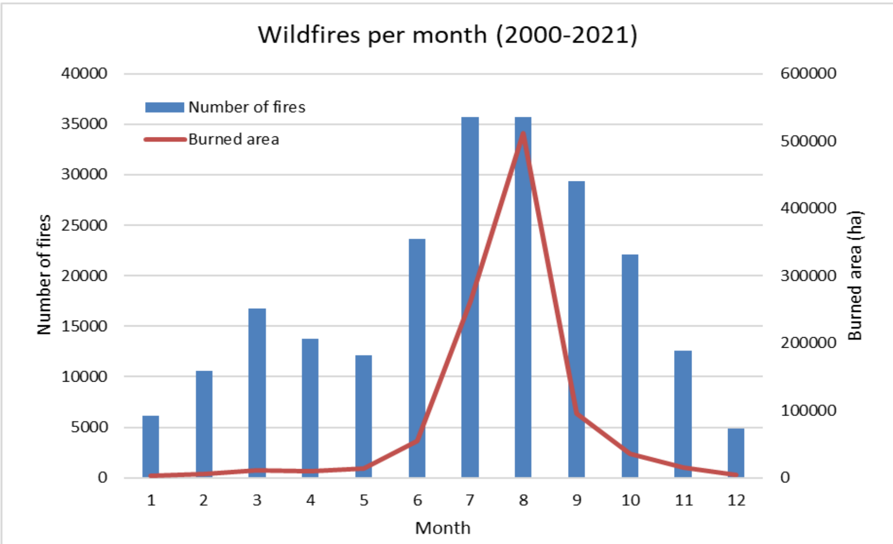


Figure 58: Above, the annual distribution of wildfire events and burned area for Greece (2000-2021), and below, the monthly distribution of wildfire events and burned area for Greece (2000-2021).

While the annually burned area in Greece has been around 40 thousand hectares on the average in the last 40 years from approximately 1,500 fires per year (>10 ha), certain years stand out as exceptionally catastrophic such as indicated from the European Union's wildfire history statistics (EFFIS 2020). These are the years of 2000 with 145,033 ha and 2007 with 225,734 ha burned in the 21st century. More than 28,000 ignitions occurred during the years 2000 and 2001. The largest historical fire events for the prefectures of Greece took place in the record years of 2007 and 2021 in the region of Peloponnese, namely in Achaea (30,000 ha), Messenia (11,000 ha), Laconia (22,000 ha) and Ilia with four wildfires (40,000, 32,000, 30,000 and 12,000 ha). Forest fires of 2021 in Greece amounted to 140,000 ha burned, from six large-scale events (more than 5,000 ha each) and one mega-fire in Evia (46,000 ha). In 2000 the fire of Samos Island in the north-eastern Aegean burned 14,500 ha, summing up to a total of 18,000 ha burned during that year in the region. Evia also experienced a large-scale event during 2007 with 18,000 ha burned. During 2012, a large fire on Chios Island burned 15,000 ha including a significant area occupied by the precious and unique socioeconomically mastic producing tree (*Pistacia lentiscus* var. chia).

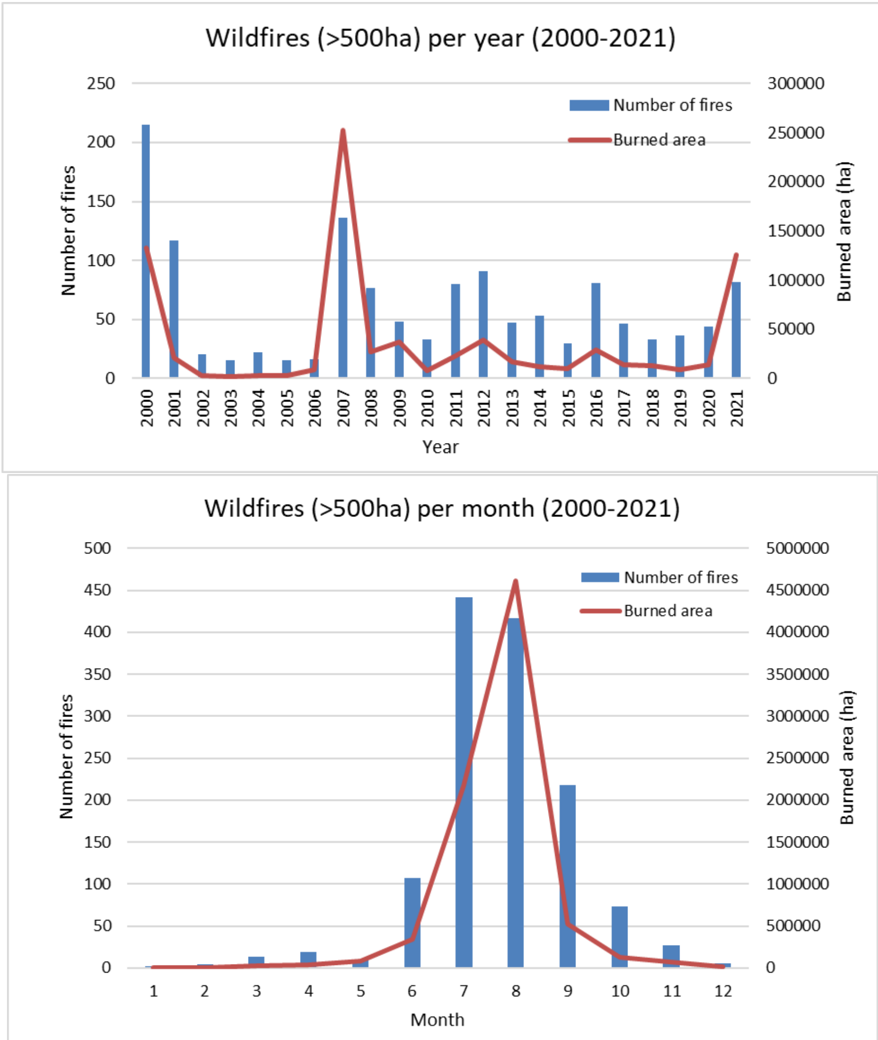


Figure 59: Above, the annual distribution of large wildfire events and burned area for Greece (2000-2021), and below, the monthly distribution of large wildfire events and burned area for Greece (2000-2021).

Between 2022 and 2024, the Fire Service recorded a total of 27,890 forest fire incidents, resulting in the burning of approximately 190,000 hectares of land. The peak fire activity was concentrated in the months of July and August (see Figure 60). Although 2022 experienced the highest number of fire events (9,856), the total area burned that year was relatively small, at 12,511.2 ha. In contrast, the burned area in 2024 was nearly four times greater than in 2022, despite the number of fires in 2024 being comparable to that of 2022. Although the total number of wildfires in 2023 was lower compared to 2022, the average fire size increased substantially, rising from 13 ha per fire in 2022 to 156 ha per fire in 2023. As a result, a significantly larger total area— more than 140,000 hectares— was burned in 2023. Notably, 92.5% of this burned area occurred during the month of August, indicating an extreme concentration of fire activity within a short time frame.

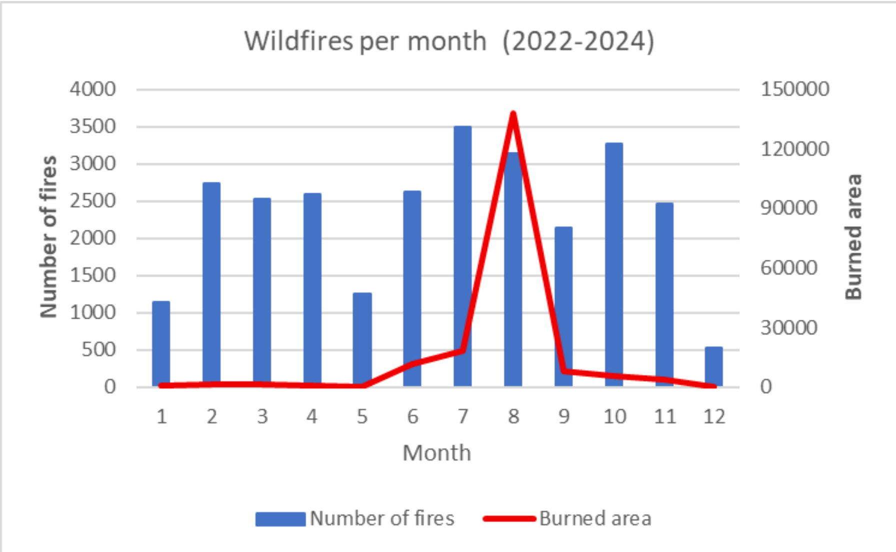


Figure 60: The monthly distribution of large wildfire events and burned area for Greece (2022-2024).

According to an analysis of wildfire data from 2020 to 2024, most fire occurrences in Greece had burned areas of less than one hectare, indicating a limited spatial extent. Over 83% of all incidents reported each year were consistently in this smallest size class, suggesting a predominance of low-intensity, rapidly extinguished fires. Although there was a slow decrease in these minor fires from 2020 to 2023, there was a slight increase through 2024. Over the course of the five years, fires that affected areas ranging from 1 to 100 hectares exhibited a relative stability, accounting for 7% to 10% of all events each year. On the other hand, larger fires, especially those greater than 100 hectares, were much less common, representing less than 1% of all wildfires each year. However, their interannual variability and increasing occurrence, especially in the category of fires over 500 hectares, suggest a concerning trend. For example, in 2020, these huge fires accounted for only 0.05% of all events; by 2023, that percentage had increased five times. These trends suggest that fire regimes may be changing, with fewer but more intense wildfire occurrences. This could be related to conditions that are more conducive to fire spread, like extended drought, heat waves, and fuel accumulation. This emphasizes the necessity of adaptive fire management plans that take into consideration the intensity and spatial impact of fires in addition to their frequency.

Fire regime groups (FRGs) characterize the distinctive ways in which fires occur in ecosystems over long periods of time, based on variables like frequency, intensity, size, season, pattern, type of fire -surface, crown, ground-, and severity, depending on whether fuel availability or climate are the main factors limiting fire behaviour, these regimes vary. The LANDFIRE project (Ryan & Opperman, 2013) used classifications to establish fire regimes and allocate them to Greece's primary plant types. The country's ecosystems were categorized into one of the four commonly recognized FRGs—understory, stand-replacement, mixed-severity, or non-fire—using data from the Greek Forest Service on the frequency and intensity of fires (Table 14).

Table 14: Categorization of historical fire regimes in Greece that describe the general frequency and severity of fires, grouped into five fire regimes (Kalabokidis et al., 2024).

Group	Frequency	Severity	Description	Forest cover type
FRG-I	0–35 years	Replacement	Generally, includes high-severity fires that replace up to 75% of the surface fuel layer	Low thorny shrubs (phrygana); low-elevation grasslands (<800 m)
FRG-II	<100 years	Mixed to replacement	Fires that replace more than 75% of the upper canopy layer (also called high-severity fires)	*Pinus brutia*; *Pinus halepensis*; *Pinus pinea;* Mediterranean shrubs (maquis) at elevations <800 m
FRG-III	35–200 years	Low to mixed	Generally, mixed-severity fires that occasionally may become stand-replacement; can also include low-severity fires	*Pinus peuce*; *Pinus leucodermis*; *Pinus sylvestris*; *Cupressus sempervirens*; *Quercus* spp. (deciduous & semi-deciduous); *Castanea sativa*; *Acer* spp.; *Tilia* spp.; high-elevation grasslands and shrubs (>800 m)
FRG-IV	35–200 years	Low to mixed	Mixed-severity fires that under adverse conditions may become stand-replacement; can very often include low-severity fires	*Pinus nigra*
FRG-V	200+ years	Any severity	Generally, can include fires of any severity	*Abies* spp.; *Picea abies*; *Fagus* spp.; *Betula pendula*

Wildfire management of the various forest types needs to take into consideration the fire regime group to which they belong, that as a rule is linked to the adaptation of the particular species to fire effects (damage severity, capacity for post-fire regeneration), and the fuel hazard they represent (characteristics as fuel accumulation rate, fuel loading and arrangement, and ultimately fire behaviour). Thus, understanding fire regimes is essential to predict fire behaviour, assess ecosystem resilience, and plan appropriate fire suppression or prescribed burning. The fire regime groups (FRG I-V) of Greece are shown in Figure 61.

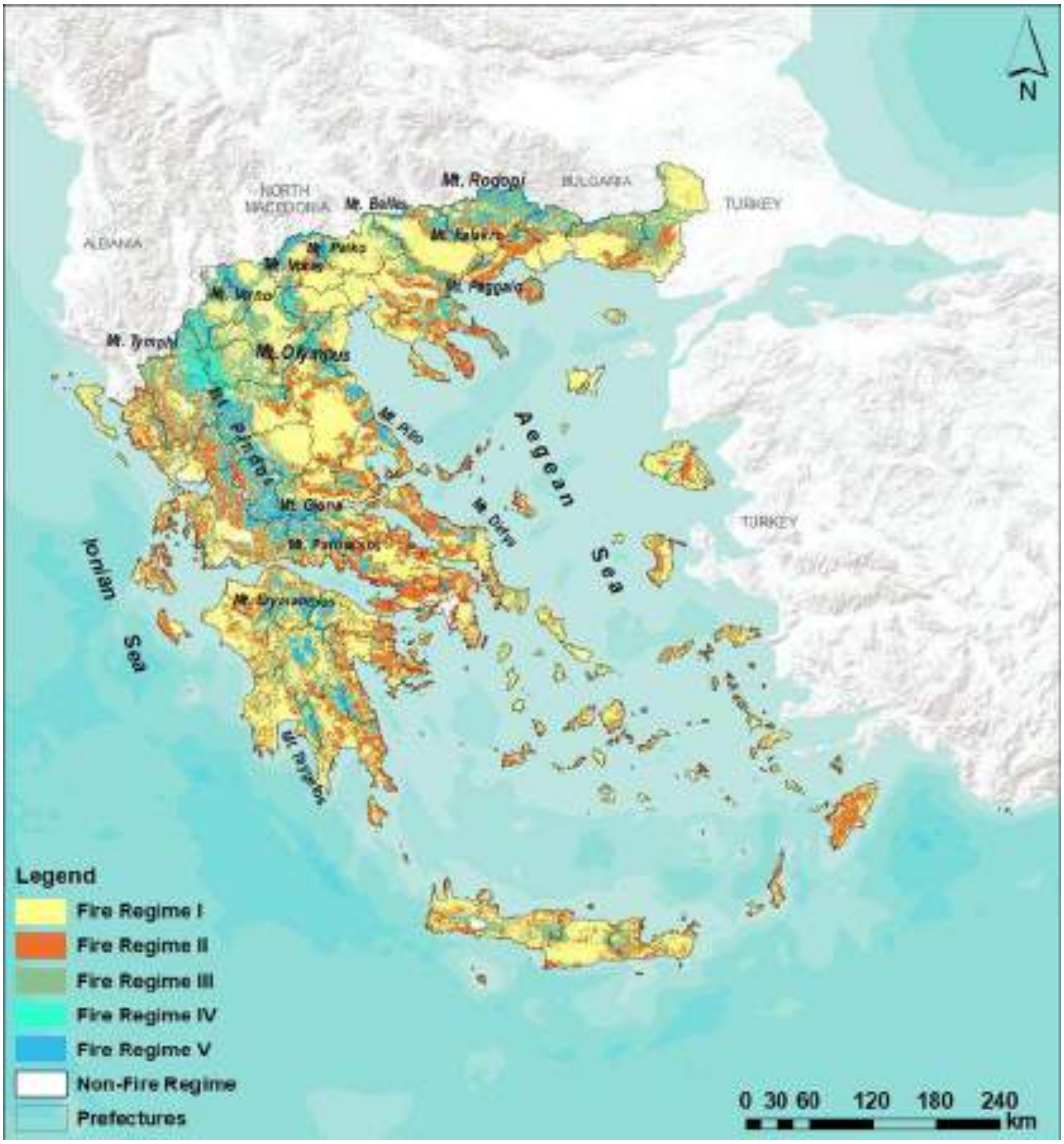


Figure 61: Fire regime groups of Greece (Kalabokidis et al., 2024).

The fire regime group I (FRG-I) is the most extended, covering 44% of Greece, that includes high-severity fires that replace up to 75% of the surface fuel layer. Low thorny shrubs (phrygana) and low-elevation grasslands (at <800 m elevation) show strong adaptation to frequent, high-intensity fires with minimal soil impact due to short flame residence time. Although fires can fully consume aboveground vegetation, rapid regeneration typically follows. Suppression strategies should reflect the site's potential to support more complex plant communities. In arid areas like the Aegean islands, low rainfall and high evapotranspiration limit the growth of more demanding species. This vegetation typically regenerates well after fire due to its adaptations. However, frequent fires combined with overgrazing can drive long-term degradation, replacing former forests with persistent shrub cover (e.g., *Phlomis fruticosa*). These degraded systems, especially on limestone soils in western Greece, demonstrate potential for ecological restoration through reforestation, grazing protection and proactive fire management. FRG-I is found on the large plains of Greece (Thessaly, central Macedonia, western Greece, and central Greece), over the Aegean islands and Crete.

The fire regime group FRG-II covers the 23.5% extent of Greece and includes fire-adapted species like *Pinus brutia*, *Pinus halepensis*, *Pinus pinea*, and Mediterranean shrubs (maquis) typically found below 800 m elevation. These species generally regenerate well after fire, but frequent re-burns (<14 years) can delay pine seed production and natural regeneration. Evergreen shrubs are susceptible to excessively high fire frequency, resulting in ecological damage and soil erosion. High fuel loads in open pine forests with dense shrub understory contribute to extreme fire intensity. These ecosystems are common in densely populated and WUI areas, posing risks to human safety and infrastructure. Focusing only on suppression risks, the “fire paradox”—accumulated fuels leading to more destructive fires. Effective management should combine fuel control, urban planning, fire prevention, public education, and resilient post-fire restoration. FRG-II is dominant on several Aegean islands (Lesvos, Rhodes, Samos, and Chios), Crete, Attica, Evia, Peloponnesus, and the coastal parts of Macedonia.

Fire regime group III (FRG-III) covers 12.5% of Greece. It is comprised mostly of broadleaf species and some high-elevation conifers, shrublands, and grasslands. Found in high-elevation forests with short fire seasons and low ignition frequency. Fuel accumulation is slow and human-caused ignitions are rare. Fires occur at intervals of 35 to 200 years but can be high-intensity, especially in older, fuel-rich stands. Intensive fuel management is generally not necessary across the broader landscape. Priority should be on active forest management (e.g., shelterwood cutting, or understory burning) in high-risk areas. Continuous monitoring during fire season is crucial to detect high-danger days. Initial attack capacity must be strengthened to prevent wildfires from burning for many days, especially in areas with low road density and rough topography. The FRG-III is dominant in the northern parts of the country (from western Macedonia to Thrace).

Fire regime group IV (FRG-IV) covers only 1.5% of Greece, mostly in the northern parts of the Pindus Mountain range, comprised of *Pinus nigra* conifer stands with a fire circle between 35 and 200 years and low to mixed fire severity. High-intensity, stand-replacement fires are more likely, so a strong, rapid initial attack, often with aerial support, is essential to prevent large-scale damage.

Lastly, the fire regime group V (FRG-V) covers 6% of Greece, mostly on higher elevations of mountain ranges (Rodopi, Pindus, and Olympus) with a fire circle of more than 200 years producing any severity fires, depending on weather and site conditions, comprised