European Commission

# FOREST FIRES

## Sparking firesmart policies in the EU

*Research & Innovation Projects for Policy*

*Research and Innovation*

**FOREST FIRES — Sparking firesmart policies in the EU**

European Commission
Directorate-General for Research and Innovation
Directorate I — Climate Action and Resource Efficiency
Unit I.3 — Sustainable Management of Natural Resources

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European Commission

# FOREST FIRES

## Sparking firesmart policies in the EU

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# FOREWORD

Dear policymakers, practitioners and scientists,

Last year in Portugal and just a couple of months ago in Greece, we learned at great cost that wildfire risk is an ever present and increasing threat in Europe. Extraordinary in their size, intensity, and severity, 'megafires' are challenging the capacities of national wildfire protection programmes and represent a major concern for the Union. EU solidarity and support are active at all stages in fire prevention, during the crisis management and in the post-disaster reconstruction.

Since 1989, the EU has been funding research on forest fires. The Sendai Framework for Disaster Risk Reduction clearly recognises the strong role that science can play in improving our understanding of wildfire risk and communicating on new knowledge and innovation.

In the aftermath of the tragic events of last year the European Commission has taken several initiatives, including taking stock of 20 years in forest fire research, to open new perspectives for future forest fire risk management and governance in Europe.

Stemming from the conclusions of EU research and innovation projects and of multistakeholder workshops, this report is timely for initiating a permanent dialogue between science, management and policy actors to exchange visions and know-how. It brings forward the concept of Integrated Fire Management and offers a wide portfolio of solutions to prevent and combat forest fires.

Making the wealth of knowledge and the implications of such knowledge available for developing forest fires risk mitigation strategies is a pre-requisite to implementing adequate policies and to better protect the European citizens, the economy and the environment against megafires.

I hope the recommendations of this report will serve as a call to action and will reinforce the exchange of information and collaboration within the EU forest fire community.

I would like to thank all EU staff and experts who contributed to the report with their hard work, dedication and enthusiasm.

**Carlos Moedas**,
Commissioner for Research,
Science and Innovation.

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# EXECUTIVE SUMMARY


Forest fires constitute a serious and increasing threat throughout Europe, and in particular in Greece, Spain, France, Italy and Portugal. Despite a decreasing trend in the number of fires and areas burned, observed in some countries since the 1980s, larger and more damaging fires (i.e. 'megafires') are challenging the suppression capacities of many wildfire protection programmes across Europe. This trend is the result of unbalanced policies that can be effective in fire suppression in normal weather conditions but are insufficient to prevent extreme events such as megafires.

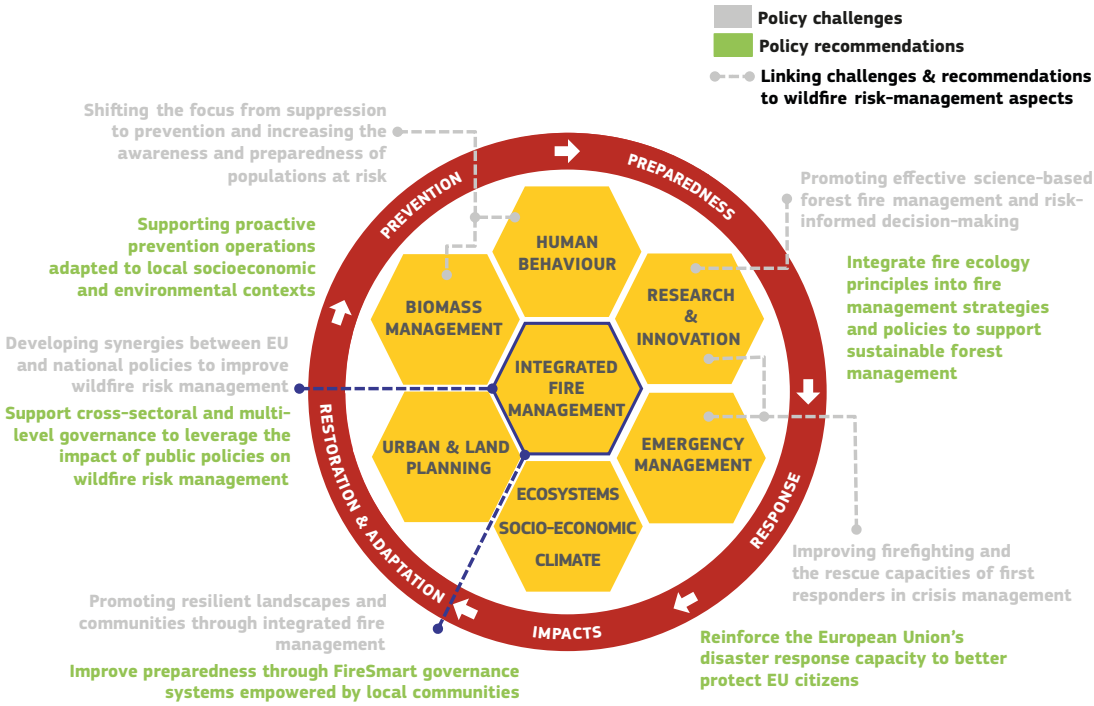
Megafires ignite and propagate in very severe weather conditions, which often makes them extraordinary due to their size, intensity and deep and long-lasting social, economic and environmental impact.

The EU has been funding research in the field of forest fires over the last two decades through its Framework Programmes and other funding instruments. About 60 research projects, from large-scale integrated projects to more traditional projects or Marie Skłodowska-Curie individual fellowships, received a total EU contribution of more than EUR 100 million. This document critically reviews the results of EU research on forest fires with a view to exploring policy adaptation to face the new challenges imposed by megafires. The review demonstrates that EU-funded research has stimulated advances in fire knowledge, operational management and decision-support mechanisms while enhancing cooperation between the key actors. The review highlights specific areas for improvement.

- There is a tendency to favour fire suppression, with its straightforward short-term results, over the long-term investment effort required for prevention (including climate-change adaptation), which could improve the effectiveness of wildfire protection programmes.
- The concept of integrated fire management provides a very useful framework that includes the consideration of the various socioeconomic and environmental aspects associated with fire management.
- EU Member States face similar forest fire risk-management issues but use different standards of training, competencies and operations. Harmonised information systems for emergency response, wildfire prevention, risk monitoring and data collection would ensure better cooperation, coordination of resources and knowledge transfer between agencies and stakeholders.
- Local specificities (e.g. fire weather, socioeconomic activities, land-use and vegetation dynamics, cultural perception and awareness of the risk) are critical to understanding and managing wildfires and should be integrated into fire-related policies at local, national and EU levels.

The analysis of the knowledge, methodologies and technologies produced in the last two decades opens up new perspectives for forest fire risk management in the face of climate and environmental changes, social and cultural trends and growth dynamics. Based on the findings of the review and the conclusions of a multi-stakeholder workshop, key recommendations have emerged and are proposed for a more extensive dialogue between the key actors to improve forest fire risk management in Europe.

## GRAPHIC 1. Policy recommendations for improved forest fire risk management



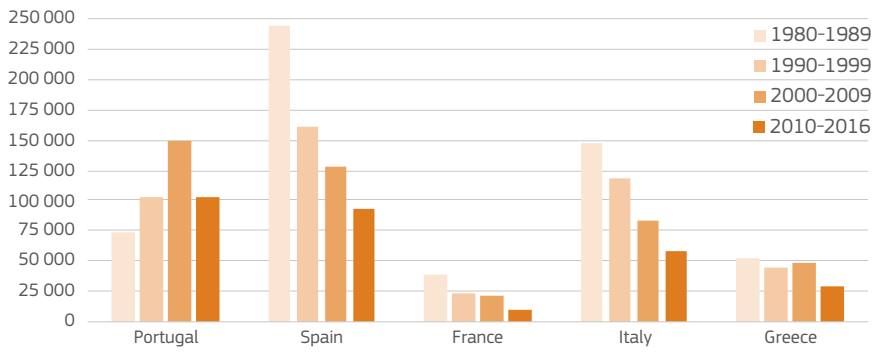

The set of policy recommendations follows the logical sequence of the fire management cycle and addresses the main human, physical and environmental elements with an impact on the risk-management process (see figure). The proposed recommendations should be taken into account in light of the corresponding policy challenges (identified by evidence-based science) and support the overall EU policymaking process.

# INTRODUCTION

# 1. RECENT FOREST FIRE TRENDS IN EUROPE

Forest fires (the term used in Europe to designate the unwanted fires burning forests and wild lands; also referred to as 'wildfires' in this report) are a major hazard throughout Europe, producing large environmental and economic losses and having an impact on human lives. Over 40 000 fires per year were reported between 2010 and 2016 in Greece, Spain, France, Italy and Portugal, where most of the burned area is located (approximately 85 % of the total burned area in Europe). The surface affected by fire every year between 2010 and 2017 amounts to 350 000 hectares. A noticeable decrease in the number of fires and in the total burned area has been reported in the countries affected most, except for Portugal, since the 1980s (see Figure 1). However, these average values vary greatly from year to year; it has been observed for a given year that the average area burned was double or triple that which was burned in the preceding years. Due inter alia to climate change, analyses of European forest fires occurring in the last 30 years show an increase in the length of the fire season, with extreme fire events also occurring in June and October, at the edge of the traditional fire season.

**FIGURE 1. Average area burned (ha) per year by forest fires over the last several decades in the five largest countries in southern Europe.**




*Source:* EFFIS.

## The impact of forest fires in the EU in the 2000-2017 period

- Environmental losses: **8.5 million ha** burned, approximately 480 000 ha/year.
- Human losses: **611** firefighters and civilians killed, nearly 34 people/year.
- Economic losses: over **EUR 54 billion**, approximately EUR 3 billion/year. Under rapid economic growth and increased greenhouse gas emissions, the economic impact for Greece, Spain, France, Italy and Portugal may increase to over EUR 5 billion/year by 2070-2100.

*Sources:* European Forest Fire Information System (EFFIS), EC PESETA II project report.

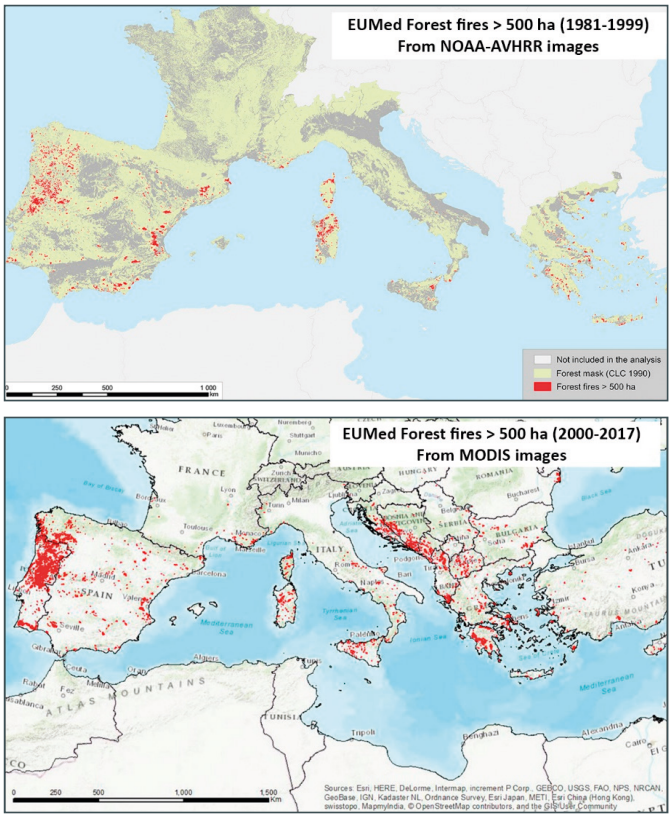
# 2. EUROPE IN A NEW WILDFIRE CONTEXT

A long history of human land use, climate variations and associated disturbances such as fire have shaped most European landscapes, in particular the current mosaic-like vegetation patterns of Mediterranean ecosystems. Fire is a natural component driving the evolution and adaptation of native plant species in many fire prone ecosystems across Europe. The problem lies in the changes in fire frequency, size and intensity, to which neither ecosystems nor communities are adapted. Large-scale and more intense wildfires are becoming an increasing concern [1]. The occurrence of such extreme wildfire events is determined by two fundamental factors: the weather conditions and the fire proneness of forested landscapes. In unfavourable meteorological conditions such as heatwaves, these extreme wildfire events, or megafires, may occur in the course of a few days, with multiple very large fires simultaneously burning sizable portions of a whole territory or country. In Greece, 2018 was the last year in which a series of tragic events occurred, starting in the Spanish Levante in 1994, and then occurring in Portugal (2003, 2005 and 2017), Spain (2006 and 2017) and Greece (2000 and 2007), to name some of the worst cases.

This new wildfire context is defined by extreme fire behaviour characterised by rapid fire spread, intense burning, long-range fire spotting and unpredictable shifts. In addition to their serious ecological impact, extreme wildfire events have an extraordinary socio-economic impact in terms of both loss of human life and economic damage. Most damage caused by fires is due to extreme wildfire events, which only account for about 2 % of the total number of fires.

1 Tedim, F. et al. (2018), 'Defining extreme wildfire events: difficulties, challenges, and impacts', ***Fire***, Vol. 1, No 1, p. 9.

**FIGURE 2. Occurrence of forest fires with burning areas of over 500 ha during the 1981-1999 period (top panel) and during the 2000-2017 period (bottom panel).**




*Sources:* FUME project 'Lessons learned and outlook' and EFFIS (Copernicus Emergency Management Service).

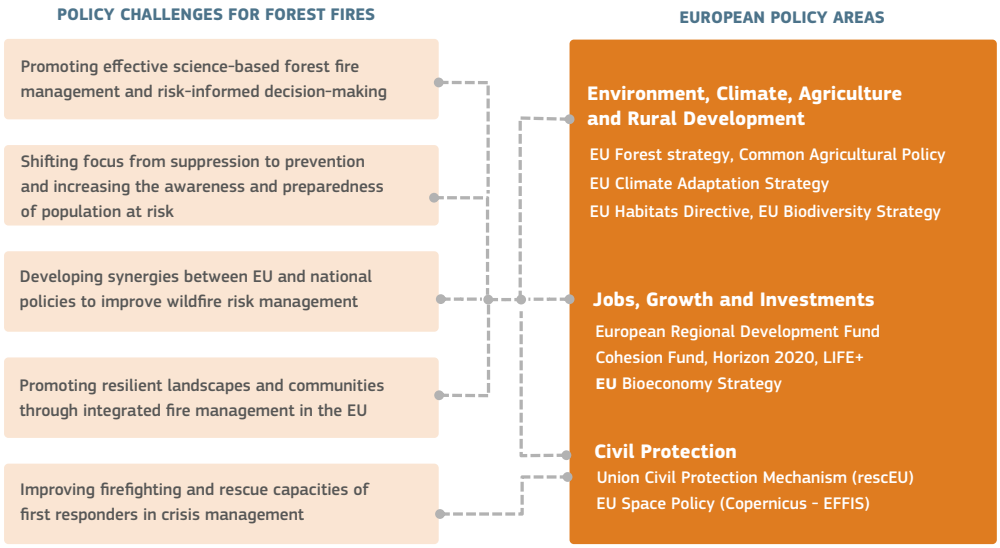
The trend in recurring and tragic fire seasons in Europe reflects the limits of conventional wildfire and forest management strategies and programmes in efficiently addressing the phenomenon. Progress has been made to date at different levels, including the revision of national forest programmes, the development of criteria and indicators of sustainable forest management and voluntary codes of best practice. However, the growing number of extreme wildfire events indicates that contemporary land-management strategies need to account for the disturbance regimes and ecosystem types that define fire prone landscapes. This new context calls for more effective **science-based forest fire management** and **risk-informed decision-making** which account for the socioeconomic, climate and environmental roots of wildfires. This also means **shifting the focus from suppression to prevention** within the framework of integrated fire management and **increasing the awareness and preparedness of populations at risk.** Addressing the new context of wildfires in Europe will therefore imply strengthening European cooperation on forest fire risk management through **effective synergies between EU and national policy objectives and territorial governance.** As a result, more balanced and **sustainable forest management**[2] strategies that integrate prevention, climate adaptation, education, preparedness, suppression and restoration aspects could be implemented.

2 Sustainable forest management is 'the stewardship and use of forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national and global levels, and that does not cause damage to other ecosystems'. Ministerial Conference on the Protection of Forests in Europe. Resolution H1 of Helsinki (1993).

# CURRENT POLICY CHALLENGES

EU Research & Innovation (R & I) has played and continues to play a key role in identifying and addressing these policy challenges by opening avenues for sustainable change, harnessing misconceptions of the what, how and why, in favour of evidence-based decision-making and management of forest fires in Europe.

A recent scientific review of EU R & I projects contributed to identifying some of the main policy challenges related to forest fire risk management and governance, which can further be addressed by the relevant EU and national policies.




## 1. PROMOTING EFFECTIVE SCIENCE-BASED FOREST FIRE MANAGEMENT AND RISK-INFORMED DECISION-MAKING

There is a vast amount of information on wildfires at local, regional and global levels. However, **one major challenge is ensuring that the practice of fire management and its associated governance are making full use of science-based findings and innovations.** Specific efforts should be devoted to improving knowledge transfer to and exchange with practitioners and decision-makers, notably with regard to the following.

'R & D's immediate priorities lie on governance, fire management and risk, information and public behaviour on rural landscapes.'

*Tiago Oliveira — President of the mission structure for the installation of the integrated management system of rural fire in Portugal.*

- **Fire behaviour and trends.** Wildfire risk is determined by a combination of many factors, including vegetation, climate, forest management practices and other socioeconomic parameters. Management actions and deployment of resources to deter fires are planned based on where and how fires occur. Hence, precise fire mapping and statistics describing how wildfires are changing in time and space are deemed essential for assessing the role of driving factors such as climate, land-based features, fire policies, etc. Policymakers and management agencies require information on wildfire probability, behaviour and spatio-temporal trends to manage fire prone landscapes and to evaluate the efficacy of prevention plans. Territorial and environmental policies have great potential for addressing the structural causes of fire ignition and propagation in the long term.


- **Wildfires and climate change.** Climate change affects forest fires, both directly through the weather conditions that affect fire ignition and propagation, and indirectly through its effects on vegetation and fuels. Forest planning actions are scheduled with a timescale of a few decades, which requires taking into consideration how the climate will change and its impact on future forest health and fire conditions. Understanding how future climate change will continue to affect forests and their fire proneness in Europe is important in determining fire adaptation and the mitigation potential of forests and natural areas. Furthermore, we need to prepare EU forests and the forest sector to address the nature and magnitude of the challenges posed by climate change. Doing so will depend on the different territorial scenarios existing in Europe on different spatial scales.
- **Fire ecology.** Landscapes are a reflection of past uses and land-management actions, in particular in southern Europe where wildfires are frequent events. In a context of changes in wildfire regimes, climate and vegetation legacies, managing these ecosystems to maintain the services they provide is a challenge. To this end, providing information about how ecosystems respond to fire is most relevant for managing landscapes and planning post-fire recovery.
- **Fire and people.** Coexistence with wildfire is strongly influenced by the type of fire regimes that operate in a given landscape and the degree to which communities can reduce exposure and vulnerabilities there. Changes in the social and economic characteristics of the population can influence current fire activity in a given area. Wildland–urban and rural–urban interfaces are the spatial manifestation of the coupling of fire and people, and the most proximate scale of exposure and risk mitigation. Advancing our understanding of people's perception of fire management and policies is a prerequisite for their successful implementation.

## 2. SHIFTING THE FOCUS FROM SUPPRESSION TO PREVENTION AND INCREASING THE AWARENESS AND PREPAREDNESS OF POPULATIONS AT RISK

In many countries outside Europe, such as the United States, the transition from complete emphasis on fire control to more integrated fire management policies occurred as a result of catastrophic fires that caused distress in firefighting systems and required continual budget increases. Similar trends have been observed to a relatively lesser extent in Europe. The importance and value of forest fire prevention has been demonstrated through various research projects in the Mediterranean region. Currently, fire prevention forms part of the fire management policy in all southern European countries, however it does not receive the necessary emphasis

and funding compared to fire suppression. Similarly, the preparedness of agencies and communities to deal with extreme fire events is often far from optimal.

> 'Without extinction, prevention is useless but without prevention, extinction is impossible.'
>
> *EFIRECOM project*

- **Fire weather and fire danger rating.** Fires typically occur in certain meteorological conditions. Fire sensitivity to changes in weather varies from place to place. For operational purposes, fire weather indices based on meteorological variables are used for predicting fire ignition and spread potential. A proper understanding of how the meteorological conditions influence fire spread and intensity is imperative for accurate forecasting of fire danger. Improving meteorological diagnostics and fire danger forecasts would lead to a more effective use of fire suppression resources and planning of emergency operations.
- **Fire preparedness.** Large and very intense forest fires are occurring in many different regions in Europe and the various agencies and communities are generally not prepared to cope with these new challenges. The preparedness of agencies and communities to deal with those events requires adequate evaluation of risk and timely communication through the development of early-warning systems, as well as training of personnel for efficient emergency operations, including evacuation or confinement plans. This also entails developing public awareness and education and addressing the misconception that fire protection is the sole responsibility of the fire department
- **Wildland-Urban Interface.** The depopulation of rural areas and the expansion of urban areas in western Europe has led to the creation of important interfaces between houses (and other built infrastructures) and forests and other vegetation types with accumulated biomass. When burning, such a high fuel load can create very significant threats to people and make firefighting and other civil-protection operations much more difficult to coordinate. This situation, known internationally as the wildland-urban interface or the rural-urban interface, has contributed to more intense wildfires that are able to devastate large geographic areas, causing significant loss of human life and property. Limiting the sprawling of WUIs and mitigating the impact of wildfire in these interface areas elicits many social and scientific challenges, such as establishing construction and development standards, defining asset-protection zones with proper fuel management and predicting fire spread and behaviour in interface areas and making this information available to the public for a better response in case of emergency.

- **Fuel management.** Changing socioeconomic conditions in rural areas have contributed to changing forests in terms of area, growing stock and structure. These changes are thought to be key factors in determining the increased frequency and impact of wildfires throughout the continent in the last century. The increasing trend in fuel load and continuity in southern Europe can also be attributed to land abandonment, inadequate landscape and forest management, and fire exclusion policies. The projected increase in drought severity and associated increase in fuel flammability due to climate change are further intensifying forest fire risk beyond existing fire prone areas. Hence, there is a need to integrate forest fire prevention principles in land- and forest management strategies.

'To prepare for megafires, we don't need more resources, we need better managed landscapes.'

*Marc Castellnou — Catalunya Fire Service*

## 3. IMPROVING FIREFIGHTING AND THE RESCUE CAPACITIES OF FIRST RESPONDERS IN CRISIS MANAGEMENT

- **Land, aerial and space detection.** In extreme weather conditions a fire start can rapidly develop into a large and intense wildfire with catastrophic effects. Timely and accurate detection requires the integration of fire behaviour and forest knowledge at strategic and tactical levels. Rapid wildfire detection is therefore fundamental to coordinating and performing a quicker and stronger initial attack.
- **Firefighting techniques and technological tools.** The increasing intensity of wildfires, together with the increased concern about fire safety and costs, requires better strategies and tactics for firefighting. There is a strong need for professional development in firefighting and the promotion of safety practices for firefighters in order to face extreme wildfire events in Europe. Successful professional development in firefighting depends on the integration of training and education, which are aligned with the principles of integrated fire management. Common Incident Command Systems and common standards on capacity building for emergency training at European level are needed for enhancing international firefighting assistance.
- **Fire safety.** Safety is a key issue for all involved in fire management. Research has been dedicated to the selection of appropriate firefighting protective equipment, but also to the promotion of safety concerns for current and potential vulnerable areas (e.g. in the WUI) and groups such as tourists. Awareness campaigns focusing on fire safety, but also on the optimisation of operations — such as firefighters' equipment and the use of forest roads for evacuation and for safe firefighting — are all part of the fire safety issue. The major challenges for dealing with this aspect of fire suppression lie in the risk associated with wrong decisions that can expose lives to unnecessary danger. As decision-making relating to safety concerns is delicate and complex, strong cooperation and the exchange of experiences and lessons learned in Europe and worldwide are necessary in order to be in a position to recommend new options in this area.

# 4. DEVELOPING SYNERGIES BETWEEN EU AND NATIONAL POLICIES TO IMPROVE WILDFIRE RISK MANAGEMENT

Fire regimes are changing almost everywhere as a result of climate change, and land-cover and land-use change. Although most of the annual burned area is concentrated in the southern countries, northern areas such as Scandinavia have also suffered from unprecedented forest fires in the last decade. Challenges of this magnitude can hardly be managed by individual countries. However, national wildfire legislation and policies differ among EU Member States according to varying risk exposure and management strategies, political leadership and stakeholders' involvement, but also because of the different government agencies responsible for fire risk management.

- According to the subsidiarity principle at EU level, **the formulation of forest policies is the responsibility of the Member States** within a clearly defined framework of established ownership rights and national and regional laws and regulations for long-term planning [3]. The EU complements the efforts of its Member States by identifying policy priorities relating to forest fires in the context of sustainable and climate-resilient forest management, providing financial assistance to forest fire-related activities and creating a common European Forest Fire Information System (EFFIS)[4]. Nevertheless, the coherence between EU policies' objectives with respect to wildfire risk management should be improved. It is also necessary to assess the level of complementarity or coincidence between those policies and the national legislative frameworks defining the structural measures and operational activities regarding forests' and communities' protection from fire.
- At the national and subnational levels, territorial policies have a role to play in solving the wildfire problem at the prevention and propagation stages, but also in raising risk awareness, notably in metropolitan, rural and wildland-urban interface areas. Significant differences exist between Member States in regard to the degree of centralisation of forest fire management and the type of agency to which the various fire management responsibilities are assigned. The influence of the **multilevel governance structure** is a key issue in wildfire management. Therefore, the involvement of multiple organisations in fire management, from national to local level, requires the clear definition of authority, functions, tasks and responsibilities, together with the effective coordination of their activities.
- Significant shortcomings can be identified in relation to the **adoption of research results by policies** and operational forest fire management, which reflects resistance due to vested interests, deeply rooted opinions, fears and traditions, inadequate information dissemination, administration constraints and, sometimes, simply resistance to change. Governance is a key aspect of sustainable forest fire management. Adequate governance mechanisms can facilitate the integration of science into operations. Similarly, transparency and openness in these governance mechanisms can increase citizens' participation and politicians' accountability, opening the way for traditional and local knowledge integration.
- Another important policy element relates to the **post-fire management of burned areas.** Whereas in all EU Member States burned areas are protected from land-use changes for a number of years after a fire, immediate and compulsory reforestation is no longer a self-evident requirement. The traditional approach for the management of burned areas in the Mediterranean region has been based on reforestation with conifers since the 19th century. Nowadays the range of alternatives is much wider (e.g. natural regeneration or passive restoration; assisted restoration through appropriate silvicultural techniques to support natural regeneration; active restoration through active seeding or plantation; and finally conversion to other non-forest uses). Yet the post-fire restoration methods currently implemented in Europe do not always take into account the fire ecology of affected forest and vegetation types.
- **The ecological role of fire and its controlled use** to achieve management objectives (e.g. ecological succession, wildlife and livestock pasture improvement, fuel reduction and wildfire suppression) is only

3 http://ec.europa.eu/environment/forests/fpolicies.htm

4 EFFIS complements national databases and aims to provide EU level assessments of situations before and after fires, to support fire prevention through risk mapping, and to promote preparedness, firefighting and post-fire evaluations. http://effis.jrc.ec.europa.eu/

reflected to a limited extent in current national policies. For instance, prescribed burning is recognised as an efficient technique of wildfire prevention but is still very controversial in some countries[5]. The legal frameworks for burning in the Mediterranean Basin range from countries that prohibit it (e.g. Greece) to those that have developed regulations and basic criteria and conditions for the use of fire (e.g. France, Portugal and some regions in Spain and Italy). Overall, there is a lack of integration of fire prevention principles in current forest- and land-management practices and policies[6]. Policy instruments creating incentives for forest and land owners to align decisions and management with the sustainable provision of ecosystem services and wildfire prevention objectives are critically needed.

## 5. PROMOTING RESILIENT LANDSCAPES AND COMMUNITIES THROUGH INTEGRATED FIRE MANAGEMENT

Forest fires are complex phenomena with structural causes rooted in land and urban planning, climate and weather conditions, human activities in the vicinity of forests and cultural traditions. Holistic solutions to manage wildfire risk in fire prone areas should therefore be based on a multipurpose strategy that appropriately considers the competing demands of forest uses with the potential risks they may involve.

Integrated fire management builds upon a combination of prevention and suppression strategies stemming from social, economic, cultural and ecological evaluations. Beyond the sole consideration of fire prevention and fire suppression, integrated fire management links the four steps of emergency crisis management, i.e. mitigation, preparedness, response and recovery.

> Integrated fire management is a concept for planning and operational systems aiming at minimising the damage from and maximising the benefits of fire.

- **Holistic approach.** Wildfires primarily affect the forestry and ecosystem service sectors, but agricultural and energy production, public health and tourism may also be impacted, causing damage to property and loss of life. The challenge is to develop integrated

5 Carreiras, M. et al. (2014), 'Comparative analysis of policies to deal with wildfire risk', Land Degradation & Development, Vol. 25, No 1, pp. 92-103.
6 Montiel-Molina, C. (2013), 'Comparative assessment of wildland fire legislation and policies in the EU: towards a fire framework directive'. Forest Policy and Economics, Vol. 29, pp. 1-6.

solutions which take into account the objectives of forestry, urban and rural development, agricultural, climate and energy policies to ensure that wildfires are managed in such a way that the safety of people and housing, economic growth and ecosystem services are maintained or increased (see Figure 3). Inside the forest domain, a multi-risk approach is needed to take into account the interactions and possible amplification processes between fire and other biotic and abiotic threats. Developing more efficient and integrated solutions requires better-informed decision-making and more cooperation and coordination, and should be supported by evidence-based research.

- **Building a common culture of risk.** The perception society has of the risk of forest fires determines to a large extent people's response in emergency situations. Forest fires are largely perceived by society as a threat. Although awareness campaigns have been effective in reducing the number of fire ignitions and promoting responsible behaviour, they often underestimate the importance of the ecological and environmental functions which fire helps to maintain. Ensuring communities' resilience to the danger of forest fires requires an improvement in the knowledge of actual exposure to the risk and the effective response in the event of an emergency, as well as a better understanding of the differences between the ecological role of fire and the risk-prevention measures associated with catastrophic wildfires.
- **Inclusive approach to the common welfare.** Prevention, extinction and post-fire restoration tasks are fundamentally the responsibility of public institutions. Nevertheless, the lack of joint responsibility shared by local communities and land owners calls into question inadequate land-use practices and negligent behaviour causing ignition in fire prone areas. In addition to involving local communities in the design and planning of prevention measures, strengthening the forest sector and promoting bioeconomy and nature-based solutions, as new ways of sustainable consumption and production, can leverage participative governance, self-protection behaviour and a sense of belonging to the area.
- **Knowledge exchange and access.** The uncertainty associated with the occurrence of extreme wildfire events requires integrated studies to understand the interaction among the main drivers of extreme fires, i.e. weather, climate, landscape structure and connectivity, fuel build-up and continuity, and social issues. This uncertainty limits the scientific community with regard to the effective operational translation of scientific results to enhance wildfire management policies and practices. Nevertheless, information about wildfire dynamics and trends should be easily accessible to all bodies involved in the fire management process to improve understanding and decision-making capacities. Finally, ecology, climate change and forest fire management principles, which are often an unfamiliar subject for educators, should be better addressed in curricula.


**FIGURE 3. The approach of integrated fire management considers each step of the management cycle and brings together the human, physical and ecological elements with an impact on the risk management process.**

# 20 YEARS OF EU-FUNDED FOREST FIRE RESEARCH

*This chapter focuses on the project portfolio analysis of the R & I projects dealing with forest fire risk management or governance.*

*The section highlights the trends, major achievements and added value of EU-funded forest fire research. In addition, the barriers, incentives and future research needs are further described. The section is a summary of a more comprehensive review report produced by a group of scientific experts. All projects mentioned in this report are listed in Annex III.*

## 1. EU RESEARCH EFFORTS

The number of projects focusing on forest fires and associated funding has been increasing since the beginning of the EU Research Framework Programmes. Interest in investigations into forest fires in the southern Member States of the EU has been steadily building and has been continuously supported by national funding sources and the various EU funding schemes at multiple levels (large or small research projects, individual fellowships, science and technology networks, etc.).

European forest fire research started slowly in the 1960s and 1970s, concentrating on the ecological role of fire, with the first research projects on forest fires associated with programmes relating to environmental protection and forests. Its significant development was only made possible by the creation of the EU research FPs, the main funding instruments for science and technology policies. The first multinational programmes, STEP[7] and EPOCH[8], were instrumental in starting pan-European forest fire research, with an initial focus on technologies such as fire modelling and automatic fire detection. More work followed under the Fourth Framework Programme (1994-1998), with projects addressing the impact of wildfires and the ecological role of fire.

Triggered by a sharp increase in the number and scale of forest fires, associated with socioeconomic changes, climate change and the difficulties of forest- and fire management policies of addressing this new context, the research efforts concentrated on the driving factors of fire risk, fire behaviour and its effects and fire suppression methods. Through the results of this research, it soon became evident that forest fires constitute a significant management challenge because they are influenced by many complex and interacting ecological, social, economic and political factors. As illustrated by the wealth of information on forest fire-related science produced in the last few decades, i.e. 400 scientific publications produced each year by Greece, Spain, France, Italy and Portugal, European research has greatly contributed to advancing our scientific understanding of the fire phenomenon. The EU has become the second-largest producer of forest fire publications worldwide, with the United States being at the forefront of forest fire research and innovation.

7 'Science and Technology for Environmental Protection' programme 1989-1993.

8 'European Programme on Climatology and Natural Hazards' 1989-1992.

# 2. PORTFOLIO OF PROJECTS AND FUNDING INSTRUMENTS

EU-funded projects relating to forest fires were reviewed, most of them funded by the ongoing Horizon 2020 and the last two Framework Programmes (i.e. FP6 and FP7). In total, 56 projects were reviewed. The type of project varied from large-scale integrated projects (e.g. FIREPARADOX, FUME) to smaller projects and individual Marie Skłodowska-Curie grants (e.g. FIRESCAPE, GRADIENT). Other research projects which emphasised the demonstration of effective forest fire management were funded under the LIFE programme (e.g. ENERBIO-SCRUB, MONTSERRAT) or under the Civil Protection Mechanism (e.g. PREDICATE, WUIWATCH).

Regarding the participating institutions, a greater participation of higher-education and research institutions was observed with a balanced representation among EU Member States. Several projects involved small and medium-sized enterprises (e.g. FIRELI, SCODEV) to bring innovative forest fire equipment and technologies to the market. EU funding also targeted coordination actions between research institutions (e.g. PHOENIX, FORESTERRA) and cooperation actions among neighbouring countries (e.g. HOLISTIC) (see Annex I for a complete list of projects). The total EU contribution to the projects reviewed amounted to EUR 103.2 million (see Table 1).

**TABLE 1. Sources of EU funding and corresponding investments for the 56 forest fire research projects under review.**

| Framework Programme/Action | Number of projects reviewed | EU contribution (million EUR) |
|---|---|---|
| Sixth Framework Programme | 1 | 12.6 |
| Seventh Framework Programme | 17 | 47.6 |
| Horizon 2020 (2014-2017) | 11 | 23.5 |
| LIFE Programme | 7 | 4.9 |
| Civil Protection Mechanism | 18 | 7.5 |
| Coordination Actions | 1 | 0.1 |
| Cross-border cooperation | 1 | 6.9 |
| Total | 56 | 103.2 |

In general, most projects concentrated on research in Europe, particularly around the Mediterranean Basin, including other non-EU countries from this area, but research was also carried out in other parts of the world. The involvement of other non-EU researchers made it possible to benefit from views from elsewhere in a cross-fertilisation experience.

The projects were divided into six thematic areas corresponding to the sequence of forest fire risk-management activities (see Table 2). **'Fire science'** projects investigated issues relating to fire behaviour modelling, fuel characterisation and mapping; fire ecology in general; historical fire spatial and temporal patterns; social aspects; and climate change. **'Fire prevention'** projects investigated issues relating to fire meteorology and fire danger rating; fuel management and adaptation measures, including prescribed burning, and use of biomass; preparedness, including risk assessment to support early warning, public communication and emergency response; risk management within interface areas (e.g. wildland-urban interface). **'Fire detection'** projects relating to 'land, aerial and space detection' focused on the rapid location of fire ignition points and rapid fire-fighting response. **'Fire suppression'** projects investigated firefighting techniques, from aerial firefighting to

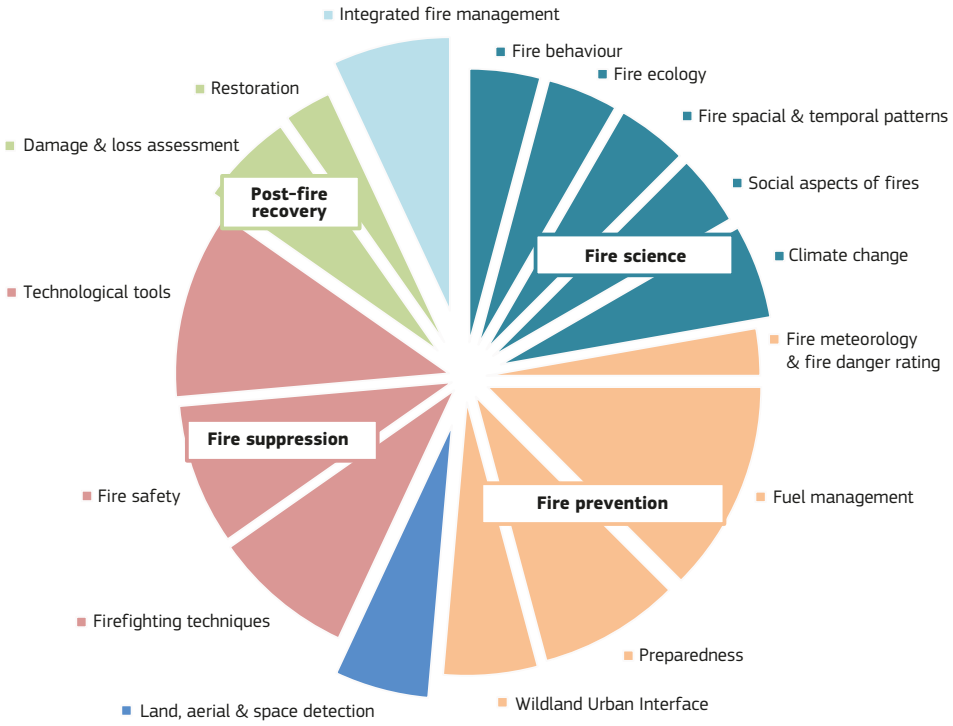
the use of fire as a suppression tool; fire safety, awareness and evacuation strategies; technological tools and innovations for improved forest fire risk management and firefighting operations. **'Post-fire recovery'** projects looked at damage and loss assessment (e.g. prediction of fire severity and ecosystem vulnerability, monitoring and assessment of the impact of fire) and investigated the potential for restoration techniques to reduce fire risk and increase resilience. **'Fire integration'** projects studied the development of integrated solutions to deal with fire management. Research investigated how several aspects relating to social and economic issues, climate change, the use of biomass for energy, tourism, territorial planning or fire risk awareness were integrated into governance and wildfire protection programmes.

The areas most addressed by EU research on forest fires are fire prevention, fire suppression and fire science (Table 2, Figure 4). Less attention has been dedicated to research topics relating to post-fire recovery among the projects reviewed.

**TABLE 2. The six thematic areas considered for assessing the contribution of research projects to forest fire risk management. Thematic areas are further subdivided into specific topic areas.**

| Thematic area | Projects | Specific topics |
|---|---|---|
| **1. Fire science** | 16 | 1.1. Fire behaviour |
| | | 1.2. Fire ecology |
| | | 1.3. Fire spatial and temporal patterns |
| | | 1.4. Social aspects of fires |
| | | 1.5. Climate change effects on fires |
| **2. Fire prevention** | 21 | 2.1. Fire meteorology and fire danger rating |
| | | 2.2. Fuel and forest management |
| | | 2.3. Preparedness |
| | | 2.4. Wildland-Urban Interface (WUI) |
| **3. Fire detection** | 4 | 3.1. Land, aerial and space detection |
| **4. Fire suppression** | 20 | 4.1. Firefighting techniques |
| | | 4.2. Fire safety |
| | | 4.3. Technological tools |
| **5. Post-fire recovery** | 6 | 5.1. Damage and loss assessment |
| | | 5.2. Restoration |
| **6. Fire integration** | 5 | 6.1. Integrated fire management |

**FIGURE 4. Relative occurrence of the forest fire research thematics covered by the projects under review.**




# 3. ACHIEVEMENTS OF EU FOREST FIRE RESEARCH

EU R & I has stimulated advances in fire knowledge, operational management and decision-support mechanisms while enhancing cooperation between the key actors.

## Advancing our scientific understanding

European countries have made a significant effort to reduce forest fire risk. Investing in research has resulted in significant advances towards understanding the social, ecological and technical aspects relating to forest fire detection, response and suppression, prevention and post-fire restoration. Scientific progress in the field of forest fire risk has contributed to the facilitation and stimulation of innovations, new management and the adoption of measures, as well as a better understanding of the risk itself.

- For instance, our understanding of **how ecosystems respond to fire** is deemed essential for managing landscapes in a context where fires are prevalent. As highlighted in the FUME, FIRESCAPE and FILE projects, the combined risks of changes in fire regimes and climate have great potential to alter plant characteristics (e.g. increase in flammability) as well as ecosystem dynamics (e.g. shifts in the dominant vegetation), through altering the balance of species and reducing post-fire regeneration. Such shifts in vegetation dominance (e.g. from Pinus to Quercus species) may occur as a result of one or consecutive fires owing to past management practices. Moreover, severe droughts can impair the balance of species and reduce the recovery of the vegetation after fire. These results are readily usable by forest managers to have an a priori vulnerability assessment of how the ecosystem will respond after a fire occurs and to develop a climate-adaptation plan to enhance their forests' resilience to climate change.
- Management actions and deployment of resources to deter fires are planned based on where and how fires occur. It is therefore essential to know **how forest fires are changing in time and space** in order to

assess how the various drivers of change, including climate, land use/land cover, fire policies and fire-fighting efforts, among others, have been influencing fire regimes in Europe. The reconstruction of fire perimeters during the last 30 years or so has made it possible to identify areas at risk in the whole Euro-Mediterranean region (FIREPARADOX, FUME and GRADIENT projects). Trends in fire frequency and burned area in southern Europe are not consistent with climate-change trends, signifying the importance of country-level structural factors. Such information on fire selectivity among the land-cover features of a landscape can be used to guide management plans.

- Forest planning actions are scheduled within a timescale of a few decades, which requires taking into consideration **how the climate will change and will affect future fire conditions.** Fire weather danger is expected to increase in Europe with climate change and will be characterised by extreme weather phenomena (EARLYHUMANIMPACT, FUME and HESFIRE projects). Climate change will therefore pose a serious threat to current fire management due to a most severe fire danger season and its expansion during the year. In addition, vegetation-fire models and climate scenarios indicate that changes in land use and land cover affecting forest productivity may constrain fires where these are prevalent today (e.g. Iberian peninsula), and that other areas such as eastern Europe may become fire hotspots under unabated climate change. The expansion of fire prone areas to, for example, high mountain areas is likely to alter the dominance of endemic species and produce a full ecosystem change.

## Science to support operational management

The practice of fire management in southern Europe does not always make full use of the innovations delivered by scientific projects. Specific efforts should be devoted to improving knowledge transfer to practitioners and decision-makers. Nonetheless, several examples from applied research projects demonstrate the effective uptake of EU R & I findings.

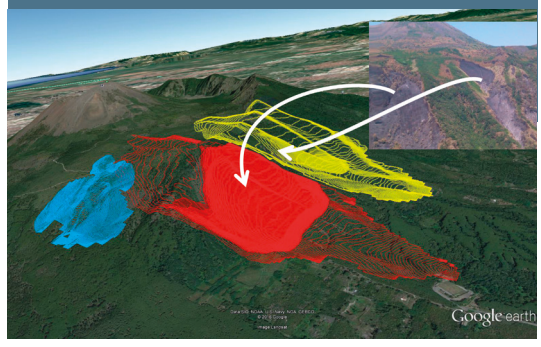
- **Knowing how to detect a forest fire in the initial stages** and how to estimate its probable propagation according to terrain, fuel and weather conditions is considered a very important issue in preventing a fire outbreak from developing into a large fire, because it allows a rapid initial attack with adequate resources. Recent technologies use networks of sensors for automatic fire detection and fire alarms. The FIRESENSE and ODS3F projects have contributed to reducing the high rate of false alarms typically associated with these systems through the development and use of appropriate sensors and algorithms.
- The increasing intensity of wildfires, combined with increased concerns about fire safety and costs, has led researchers to investigate better ways of **how to develop special firefighting techniques.** The AF3 project integrated a variety of new technologies (e.g. drone imagery) which can be managed by the commanding personnel under one system and deployed at every step of the crisis-management process. The FIREPARADOX project demonstrated and documented the potential use of suppression-fire techniques for the control of extreme wildfires that exceed the response capacity of firefighting assets. Following appropriate training, suppression-fire techniques were applied by civil-protection operators in

FIRE PARADOX

**http://www.fireparadox.org**

Advanced 2D fire propagation model called 'TIGER' and 3D (virtual reality) forest fire area simulator for teaching wildfire behaviour and providing wildfire fighting training. The simulator has been installed and is being operated at the Corpo Forestale dello Stato training centre of Castel Volturno.

**FIGURE 5. Pre-fire analysis of fire spread in the National Park of Vesuvio, Campania Region (Italy) on 20 July 2016.**



Italy and Portugal. The FIREFFICIENT project illustrated that suppression efforts, when applied in predetermined and small, carefully selected areas based on anticipatory fire behaviour knowledge, are more effective than spreading resources along the fire perimeter. These so-called strategic management points make it possible to reduce the speed at which a fire spreads and its intensity while ensuring a secure point for firefighters (DEMORGEST). Research projects have also developed multiple solutions to enhance the effectiveness and safety of current firefighting practices, notably through strengthening the capacity of fire crews on the ground. This includes technological solutions such as a new firefighting hose with retardant properties (FIRELI) or an autonomous robotic firefighting vehicle (FIREROB), as well as innovative techniques with the use of suppression fire to attack large fires indirectly (FIREPARADOX).

- Fuel management is critical in reducing the probability of fire ignition and fire propagation. As a result of fire exclusion, there is an accumulation of biomass in many European forests, causing an adverse effect on the maintenance of biodiversity, an increase in fire risk and a larger subsequent amount of wildfire damage. **How to improve fire resistance and resilience in highly fire prone systems is a major challenge of fire prevention and post-fire restoration**, which are currently managed among EU Member States according to different methodological considerations, priorities and organisational and legal frameworks. The development of an adaptive forest management toolbox (MOTIVE) for adaptive forest management under climate change has contributed to equipping forest managers with methods for strategic forest management planning. The procedures for the wise use of fire (FIREPARADOX) and the development of landscape-management and backcasting scenarios (INTEGRAL) to achieve specific management objectives are also available through several online platforms, technical guides and demonstration sites in Europe (FIREPARADOX, FUME). Given the untapped potential of biomass use in several regions of Europe (e.g. harvest/increment rate below 25 % in several regions in the south, compared to 60-70 % in terms of overall EU figures), research projects demonstrated successful examples of collaboration between local authorities and local forest and shepherds' associations to maximise the profitability of biomass extraction for energy supply and promote fire prevention, biodiversity conservation and rural development, in order to recover a more fire resilient agrosilvopastoral landscape (MONTSERRAT).

**Post-fire restoration decision support system**

**http://fumeproject.uclm.es/**

Postfire-DSS is a tool to support decision-making in the management of burned areas. It provides assessment procedures and information relating to the restoration of burned areas, in a context of climate change. The application has been successfully tested by scientists and forest managers in Greece, southern France and Italy.

## Better-informed decision-making

- Research projects have contributed to setting the basis for continued cooperation between agencies at the national level and between regions and countries on **how to cope with more severe forest fires in Europe**. The FIRELIFE and EFIRECOM projects have contributed to increasing the preparedness of the general public through adequate risk-communication and -prevention activities. This was exemplified by the production of a fire risk communication toolkit and specific assistance to national civil protection authorities (e.g. in Hungary). In addition, ANSFR and DECATASTROPHIZE respectively developed systems to evaluate fire risk assessment and management in the EU, and proposed integrated decision-support systems to assist emergency operations.
- New fire areas can emerge in places where fires have until now been limited by unfavourable climate conditions. Therefore, policymakers and management agencies require information on **how to estimate wildfire risk probability and severity at different scales.** The ARCFUEL project developed an updated geospatial methodology to classify forest vegetation into fuel types in Europe and map them. This methodology, based on EFFIS classification, allows production of reliable and accurate estimations of wildfire spread and behaviour for improved decision-making.

# 4. THE ADDED VALUE OF EU-LEVEL RESEARCH AND INNOVATION INVESTMENT

## Network building and establishing a cooperation framework

The network of research institutions established through the PHOENIX Project Centre, created within the framework of the European Forest Institute and the COST action FP0701 'Post-fire management in southern Europe', was instrumental in bringing together research efforts while providing an updated scientific baseline for developing post-fire management strategies and technical recommendations to forest managers in southern Europe. The funding provided by COST actions helps thousands of European scientists to cooperate in common research projects and to amplify the impact of research carried out within and beyond the EU Member States.

## Increased excellence and capacity building

A significant proportion of the investment in EU forest fire research is for the collective public good and has resulted, for instance, in enhancing the European knowledge base, or in marketing technologies, which would not have been financed by the private sector alone. For example, the AF3 project received EUR 12.9 million to develop, as part of its emergency-response system, a Low Power Wireless Ground Sensor Network that provides early detection and near-real-time monitoring capabilities of forest fires.

## Cross-border cooperation: avoiding redundancies and improving efficiency

The HOLISTIC project, co-financed by the European Union through the 2007-2013 IPA Adriatic cross-border cooperation programme, is a successful example of pan-European partnership between eight Adriatic countries to reduce the number and impact of forest fires, and to promote fire prevention among rural communities. The project has permitted the implementation of direct and indirect long-, medium- and short-term measures, through joint initiatives and pilot actions, which have improved fire prevention policies, fire regulations and response-coordination mechanisms across the region.

## Fostering mutual learning and harmonisation

Comparing trends between similar EU Member States has made it possible to identify differences in how they are being affected by fires nowadays and calls for a deeper understanding of the underlying causes of such differing tendencies. The ARCFUEL project designed a methodology to produce harmonised and standardised fuel-classification maps for the whole Mediterranean region, using 'readily available' spatial data sets for the Mediterranean region (JRC forest-type and fuel-type maps, multi-temporal Landsat Thematic Mapper (TM) images). The methodology was first applied in Greece and Portugal at national level and further used in Spain and Italy at regional level.

## Transferability of fire management tools and approaches

In spite of the recognised differences in conditions in the different countries and regions and because of the fruitful exchanges between partners, most of the products and knowledge delivered by research projects can be transferable and applicable to other fire prone areas. For instance, the SPITFIRE project has contributed to improving information exchange on meteorology and forest fire risk in the border area between Spain and Portugal through the identification, design and

FIREfficient
Lessons on fire

**A knowledge platform developed by the FIREFFICIENT project**

**http://www.lessonsonfire.eu**

LESSONS ON FIRE is a knowledge-exchange platform that allows generating debates, sharing quality information, finding documents in an organised way, finding expert people and/or asking a professional opinion about the integration of forest fires risk in the European landscape.

implementation of data interchange protocols and the development of a cross-border service on weather and fire risk forecasting (SPITFIRE platform). Besides the immediate positive effects of SPITFIRE for Spain and Portugal, this approach can be extended to the following borders: Spain–France, France–Italy, Italy–Austria, Italy–Slovenia, Slovenia–Croatia, Slovenia–Austria, Austria–Hungary, Hungary–Romania, Romania–Bulgaria and Bulgaria–Greece.

## 5. BARRIERS AND ENABLERS FOR IMPROVED FIRE RISK MANAGEMENT

The review identified significant shortcomings in the uptake of research findings by related policies and management approaches. A comprehensive overview of the barriers, incentives and associated research needs by thematic area is presented in Annex I. According to experts in the field, this lack of dissemination and exchange between the key stakeholders involved in forest fire management resulted in:

- relatively little change in the emphasis put on fire suppression versus fire prevention in territorial policies;
- a low level of adoption by practitioners of the concept of integrated fire management through the recognition of fire ecology principles as a key component of the management of ecosystems;
- a relatively low level of adoption of innovative fire suppression technologies and fire prevention approaches in some countries;
- very limited integration and application, in training and in practice, of the knowledge on preventive forest fire management in the context of land use and climate change.

The practice of fire management in Europe is therefore not making full use of the knowledge and innovation delivered by scientific projects. Specific efforts should be devoted to improving the transfer of knowledge to practitioners and decision-makers, while avoiding a purely reactive approach to decision-making when planning investments and communication activities. In addition, greater emphasis should be placed on funding R & I actions which encompass the full forest fire management cycle. A set of recommendations for future R & I programming is detailed in Annex II.

# POLICY RECOMMENDATIONS

*This section proposes concrete recommendations for addressing identified current policy challenges based on the conclusions from recent R & I projects funded under various EU Framework Programmes. More information on the evidence and concrete results behind the recommendations can be found on the project websites.*

## 1. SUPPORT CROSS-SECTORAL AND MULTILEVEL GOVERNANCE TO LEVERAGE THE IMPACT OF PUBLIC POLICIES ON WILDFIRE RISK MANAGEMENT

***Policy challenge***

**Developing synergies between EU and national policies to improve wildfire risk management**

There are often multiple and complex interactions between public policies influencing wildfire occurrence and propagation due to the great interdependency between forest and/or civil-protection policies with land-use planning, agricultural and rural development, environmental, climate and energy policies. These policies may have important positive or negative effects, which might support or impede the development of forest and/or civil-protection policy programmes. An integral approach to wildfire risk management therefore requires the following.

'We can design smart landscapes but we don't have the governance structures and economic engines to make them happen.'

*Inazio Martínez de Arano*
*European Forest Institute*

- **Increase the level of coherence between public policy objectives with an impact on wildfire management.** HOLISTIC showed that a cross-sectoral approach can bring together spatial planning, rural and peri-urban development, forestry, civil-protection, energy, climate, environmental and tourism/recreational policies. It should provide the opportunity to do an in-depth study of the structural causes affecting wildfires (rural abandonment, climate change, land-management practices, new policy paradigms and new urban demands), and it also should give the opportunity to identify the possibilities for intervention in relation to these (e.g. promotion of forest ecosystem services' added value, reduction in fuel accumulation, forest adaptation to climate change, etc.). In countries where the responsibility for wildfire management is shared between the forest and civil-protection services, a cross-sectoral approach is even more necessary in order to guarantee an effective collaboration.
- **Improve coordination among EU policies and national policies on disaster prevention, preparedness and response to different risks.** This includes the EU forest strategy [9], the Union Civil Protection Mechanism [10], the EU strategy for adaptation

to climate change[11], the EU regional development and cohesion policy, environmental legislation and R & I, as well as policies to deal with serious transnational threats that put health and/or property at risk, for example epidemics or terrorism. EU cohesion policy is key to disaster prevention and management, with EUR 8 billion in investment mainly addressing the prevention of and preparedness for natural disasters. Measures supported include equipment and vehicles for civil-protection units, infrastructure, forest and fuel management, ecosystem-based solutions, awareness-raising, monitoring systems, training and cross-border coordination. As part of the reform of cohesion policy, preconditions were introduced to ensure effective and efficient spending such as national or regional risk assessments, also required under EU civil protection legislation. In 2018, new opportunities to further strengthen actions on disaster-risk management in forests and better define the potential role of the EU will be provided through the review of the EU forest strategy. Effective multilevel coordination should include the main guidelines stemming from the European Union, regulatory frameworks developed at national (and sometimes regional) level and implementation plans at regional and local levels. The Fire Intuition platform[12] documents the existing legislation and policy instruments in relation to wildfires at pan-European level. This review should assist the harmonisation of wildfire regulations at EU level (FIREPARADOX).

## 2. REINFORCING THE EUROPEAN UNION'S DISASTER-RESPONSE CAPACITY

***Policy challenge***

**Improving the firefighting and rescue capacities of first responders in crisis management**

Wildfire policies adopted by most European countries over the last century have been based on fire exclusion. Forest firefighting represents a yearly budget of EUR 2.2 billion for EU governments and public agencies (SMART FIRE BARRIER). In all Euro-Mediterranean countries, the principal aim of wildfire suppression programmes is to ensure a systematic, rapid, hard-hitting initial attack on all fire ignitions. National firefighting capacities rely to a large extent on aerial resources and can therefore be insufficient in the event that adequate aerial resources are unavailable or if it is not possible to operate due to extreme weather conditions. The following recommendations aim at improving the firefighting and rescue capacities:

- **Promote the use of new firefighting products or fire suppression techniques.** Innovative ICT solutions using different ground and aerial detection systems based on cameras and sensors can be very useful in detecting fires at an early stage and incorporate that information into networks and systems to assist early deployment and initial attack (FORFIRE, FIRESENSE). Despite the potential such technologies and methodologies have to reduce costs and increase safety and firefighting efficiency, adequate legislation and regulation are required to allow for their implementation and integration into the Union Civil Protection Mechanism and firefighting activities, including training. Solving the issues relating to the standardisation and compatibility of existing forest fire equipment should also be addressed at pan-European level within a coordinated response scheme.

9 https://ec.europa.eu/agriculture/forest/strategy_fr
10 http://ec.europa.eu/echo/what/civil-protection/mechanism_en
11 https://ec.europa.eu/clima/policies/adaptation/what_en
12 http://fireintuition.efi.int/products/legislation-and-policies.fire

- Member States may take appropriate measures to **train and equip firefighters with all possible integrated fire management competencies** (FIREPARADOX). Efforts should be targeted at building up the experience and know-how of first responders on the coordination of extreme fire events through the provision of technical training on the safe and efficient use of suppression fire, water, retardants and heavy equipment by terrestrial or aerial means. Professional training certified by a European qualification framework should improve the efficiency of operational systems. In addition, early warnings and predictions of fire propagation based on terrain, fuel and weather data can complement surveillance and patrolling capabilities and support (ODS3F).
- Improve the interaction between local and national authorities and **promote the use of decision-support systems, risk-knowledge-exchange platforms and awareness-communication tools** (EFIRECOM).

In 2017, the Commission proposed an ambitious new plan to strengthen the EU's civil protection[13], including complementing national response capacities by a reserve of new civil protection assets at EU level (rescEU); a new European Civil Protection Knowledge Network to strengthen training, exercising and knowledge exchange between national civil-protection authorities; and working more closely with Member States on prevention strategies.

- Reinforce the cooperation between EU Member States and **assist first responders in the coordination of the emergency response** and in the containment of wildfires with adequate information and resources (DECATASTROPHIZE). Special attention should be given to the new fire prone areas and territories of risk, notably the WUIs.

## 3. SUPPORTING PROACTIVE PREVENTION OPERATIONS ADAPTED TO LOCAL SOCIOECONOMIC AND ENVIRONMENTAL CONTEXTS

***Policy challenge***

**Shifting the focus from suppression to prevention and increasing the awareness and preparedness of populations**

According to the Food and Agriculture Organisation of the United Nations[14], forest fire prevention may be 'the most cost-effective and efficient mitigation programme an agency or community can implement'. Despite such critical importance, prevention programmes suffer limited budget allocation compared with fire suppression, and often lack an adaptive legislative framework able to regulate fuel management activities, institutionalise pre-season preparedness activities, establish an early-warning system and prohibit potentially dangerous activities during certain fire seasons. Changing the focus from firefighting operations to long-term planning and strategic decision-making is a necessary step for fire services and should be supported through an incident command system where the operations for civil protection, landscape planning and restoration are coordinated. Such proactive prevention operations would involve:

- Developing a centralised, general planning and governance framework for fire risk management aimed at **ensuring the balance between prevention and suppression resources, and encourage operations** adapted to the local socioeconomic and environmental characteristics of each region or locality.

13 Communication from the Commission to the European Parliament, the Council and the Committee of the Regions, Strengthening EU disaster management: rescEU solidarity with responsibility (COM(2017) 773 final).

14 Food and Agriculture Organisation of the United Nations, (2006), 'Fire management: voluntary guidelines — Principles and strategic actions', Fire Management Working Paper, No 17, Rome (also available at http://www.fao.org/docrep/pdf/009/j9255e/j9255e00.pdf)

- **Prevention measures can only be effective if they combine wildfire prevention with socioeconomic and environmental benefits** such as conserving biodiversity, enhancing rural development and producing energy (BIOENERGY & FIRE PREVENTION).
- **Fire prevention must target the reduction of fire ignition as well as the management of fuels**, as these are the only factors affecting fire occurrence and propagation upon which we can act (FUME).
- **Fire prevention must integrate the long-term adaptation of forests to climate change** (MOTIVE), adopting both short- and long-term preventive measures, such as forest thinning, reintroduction of grazing, fire breaks (short-term), introducing more climate-resilient species, turning artificial plantations and simplified forest ecosystems into more natural and diversified forests (long-term). Only by integrating adaptation consideration into forest management can the longer-term climate risk be reduced.
- **Actively engaging citizens, fire services, forest management and other stakeholders** in multidisciplinary teams in fire prevention (PROMYLIFE, FOSEPOGA).
- **Increase public information on forest fire risk** (EFIRECOM, FIRELIFE) as well as the commitment of communities at risk in preparedness programmes, **and limit the frequentation of fire prone areas** during the peak fire season.
- **Developing and implementing appropriate regulations for prevention policies and emergency management** in sensitive areas such as the wildland-urban interface at the suitable level. In Portugal, for instance, 85 % of all forest fires start within 500 m of infrastructures in the wildland-urban interface[15].

According to the report of the Independent Technical Committee that was appointed for the investigation of the Pedrógão Grande fire of June 2017 in central Portugal, the cost of prevention actions in the 2011-2016 period amounted to EUR 135.8 million (EUR 22.6 million per year), while the cost of suppression in that period reached EUR 453.4 million (EUR 75.6 million per year). It was further estimated that the mean annual loss, due to fires, of goods and services alone amounted to EUR 140.8 million, and the mean annual cost for post-fire rehabilitation of the burned areas was EUR 38.9 million.

## 4. INTEGRATE FIRE ECOLOGY PRINCIPLES INTO FIRE MANAGEMENT STRATEGIES AND POLICIES TO SUPPORT SUSTAINABLE FOREST MANAGEMENT

***Policy challenges***

**Promoting resilient landscapes and communities through integrated fire management in the EU**

**Developing synergies between EU and national policies to improve wildfire risk management**

**Promoting effective science-based forest fire management and risk-informed decision-making**

The EU Forest Strategy[16], adopted in 2013, establishes a framework for forest-related actions in support of the protection and sustainable management of forests. Rural Development Programmes (RDPs) under the Common Agricultural Policy are the main EU funding instrument for forest-related actions and the implementation of the Forest Strategy. The rural development policy supports sustainable forest management through specific forest

15 Catry, F. X. et al. (2007), 'Spatial distribution patterns of wildfire ignitions in Portugal', Wildfire 2007 conference, Seville (Spain).

16 https://ec.europa.eu/agriculture/forest/strategy_en

fire prevention and restoration measures that the Member States can include in their RDPs. The optimisation of forest management strategies at landscape level under future scenarios of climate and land uses requires the following:

- **Developing an integrated fuel-management strategy** which reconciles economic and environmental objectives (FIREPARADOX). This requires a better understanding of past land-use-change dynamics, the development of innovative fuel-dynamic assessments, the integration of fire prone rural areas into fire prevention planning and the promotion of adaptive forest management methods (e.g. prescribed burning, species selection, diversified ecosystems, sylvicultural practices such as forest thinning, regeneration cuttings, reintroduction of grazing, fire breaks) to create more resistant and climate-resilient landscapes.
- **Forecasting of vegetation responses to fire and other influencing factors**. Projected trends of more severe fire regimes will increase ecosystems' vulnerability to fire, and thus the damages on vegetation and soils. In the 2000-2012 period, approximately 80 000 ha burned every year within the Natura 2000 sites, that is some 3.3 % of the total Natura 2000 area in the affected Member States[17]. Non-adapted, vulnerable protected species in the Habitats Directive are threatened by the changing fire regime and climate (FUME). Conservation policies should make use of available remote-sensing products developed by research (GRADIENT, PREFER) to incorporate the assessment and monitoring of key habitat and species responses to changes in climate change and in fire regimes into their management strategies and procedures. Post-fire impact prediction should provide the scientific basis for planning the restoration of burned areas.
- **Support for the rehabilitation of burned areas.** Based on PHOENIX recommendations, post-fire rehabilitation should always prioritise soil and water conservation, account for environmental economic and social aspects and integrate communities into long-term planning, while ensuring that law-enforcement capacities are in place. It is also essential to adopt an adaptive management approach which systematically integrates the results of previous interventions to iteratively improve post-fire management strategies. Due to the different biogeographical conditions in some areas there is a need for active and instant support of restoration actions, while in other areas more nature-driven processes could be more appropriate. The planned restoration measures should reflect the various needs indicated in the forest management

17 San-Miguel-Ayanz J. et al. (2012) Forest Fire Damage in Natura 2000 sites 2000-2012. Executive Report. Publications Office of the European Union. DOI: 10.2788/77848.

strategy and should be supported by adequate resources. The EU Forest Strategy includes orientation strategies for the Member States to build a common restoration prioritisation framework, in agreement with the 2011-2020 Strategic Plan for Biodiversity. The strategy further supports national action plans for protecting forests and soil in areas most threatened by land degradation and desertification. In both cases, restoration prioritisation and the protection of forest ecosystems are especially related to forest fires in southern European countries.

- **The regulation of the use of fire as a fuel-management and suppression tool in Europe.** FIREPARADOX and FUME demonstrated that fire has an important ecological role in the dynamics of forests and in their sustainable management. The potential use of prescribed burning to reduce wildfire risk is not yet reflected in current policies. An evolution of regulations and policies is still required in order to promote and improve fire use practices (prescribed burning and suppression fire) which are consistent with the concept of integrated wildland fire management, i.e. allowing an adequate balance between the management of natural resources and the management of unwanted fires.
- **The promotion of a risk-based approach to managing forests and biomass.** Forests in Europe's southern regions have expanded rapidly in the last few decades, notably into abandoned agricultural and pasture lands. The lack of competitive value chains and the underutilisation of resources has led to an expansion of high-density and continuous forest cover, prone to sustaining rapid fire spread. The DEMORGEST and ENERBIOSCRUB projects stressed the need for a **sustainable mobilisation of wood and other forest products for the European bioeconomy** to mitigate wildfire risk. According to MONTSERRAT, the optimal strategy for the future development of forests and landscapes lies in the valorisation of all forest roles and functions combined with effective fire prevention measures. The EU's Bioeconomy Strategy (now under revision) and the Habitats Directive are important tools in that respect to anticipate and manage possible trade-offs between short-term wildfire risk-mitigation objectives and long-term adaptation needs, in light of changing socioeconomic conditions, changing forest resources and climate change.

## 5. IMPROVE PREPAREDNESS THROUGH FIRESMART GOVERNANCE SYSTEMS EMPOWERED BY LOCAL COMMUNITIES

***Policy challenges***

**Shifting the focus from suppression to prevention and increasing the awareness and preparedness of populations**

**Promoting effective science-based forest fire management and risk-informed decision-making**

Fire management programmes must be supported by governance mechanisms based on broad social participation and diffusion processes, such as learning and exchange of good practices, in order to be effective. The interaction of all stakeholders (i.e. local communities, forest owners, fire technicians and local and regional administrations) in fire networks is therefore essential for increasing accountability, social awareness and understanding of wildfire risk. The following recommendations would contribute to address these challenges:

- **Make governance mechanisms transparent** to diminish long-standing suspicion about the objectives and associated impacts of fire-related policies. People's risk perception depends on the familiarity of and exposure to a threat and strongly influences the acceptance of the implementation of fire management programmes (FIREPARADOX). Increased dialogue between the key stakeholders can increase citizens' participation and politicians' accountability. Several indications for policymakers were suggested,

including the importance of permanent processes for the review and evaluation of existing practices of risk assessment, early-warning systems and public communication, and their consequences on public behaviour and wildfire occurrence.

- **Instil fire resilience among all communities.** Fire management is a shared responsibility and local communities must be part of the solution through a bottom-up participatory and learning process, integrating relevant traditional knowledge and practices (FIREFFICIENT). This would help to both change the perception of local communities as the eternal culprits of catastrophic fires to that of wardens of the territory, and teach people how to live with forest fires. **Empowering local actors** requires transferring the fire control competencies from institutional bodies to territorial actors. In addition, policy instruments should create incentives for forest owners to align decisions and management with societal objectives.
- **Develop broad awareness-raising campaigns to prepare societies and communication actions for targeted stakeholder groups.** MIRTO demonstrated that multilingual information campaigns focusing on raising the awareness and preparedness of tourists travelling to fire prone areas help to avoid fire-related injuries and deaths by informing people about the correct behaviour to adopt in case of emergency, warning about the probability of a disaster and changing risk perception and acceptance about certain prevention measures. Increasing tourism flows and consequences for fire hazards will require further policy guidelines to prevent forest fires, in particular in the Mediterranean Basin
- **Environmental education needs to enlarge its public audience and focus**, through working on the interaction between society, traditions and forests. It should integrate fire safety education but also the physical, emotional and monetary dimensions associated with fire risk.

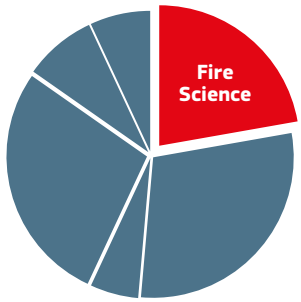
# ANNEXES

# ANNEX I BARRIERS, INCENTIVES AND RESEARCH NEEDS

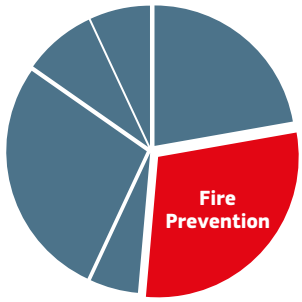
A significant number of barriers to the uptake of forest fire R & I results in EU and national policies and in operational fire management have been identified for each of the main topics. In short, these barriers relate to the inadequacies, incompleteness and uncertainties of some of the results, which lack maturity and are therefore not ready for immediate application. They also relate to an existing disconnection between science, policy and management. Country regulations, bureaucratic issues and organisational culture further add to that.

In spite of the obstacles that were identified above, there are some important incentives that have led to the incorporation of R & I results in practice so far, and are likely to lead to more uptake in the future. Incentives include the existence of significant problems that can benefit directly from specific knowledge and/or technological tools, easy availability at usable detail/scale of results, such as fuel maps, which minimise the time, effort and cost needed to invest in new approaches (e.g. fire behaviour modelling, fire prevention planning), better training of personnel, availability of funding for investment in new tools and technologies, and financial support to those participating in initiatives for fire mitigation through modern approaches (e.g. to forest landowners to carry out fuel management).

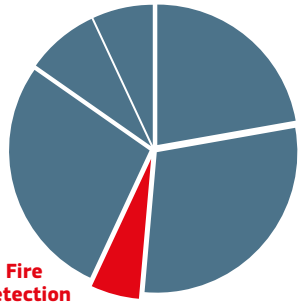
Based on the review of the projects, the following barriers and incentives for each thematic area were identified along with their associated future research needs (see hereafter). This information should contribute to the production of strategy documents (e.g. EU Forest Strategy, EU Bioeconomy Strategy and Union Civil Protection Mechanism) and to the identification of research priorities in the development of future Framework Programmes at the EU and national levels.




| | Barriers | Incentives | Research needs |
|---|---|---|---|
| Fire behaviour | > Fuel mapping lacks harmonised methodology at EU level<br>> Uncertainty in predicting extreme wildfire behaviour<br>> Allocation of fire suppression resources needs better forecasting and modelling of fire behaviour at the Wildland-Urban Interface | > Improved cooperation between wildfire management agencies and researchers<br>> More exchanges of operational fire experts between countries or regions<br>> Promotion of common standards of fuel characterisation for all fire prone EU regions | > Impact of extreme climatology (heatwaves, wind dynamics) on fire propagation<br>> Identification of the conditions (combinations of weather, fuel and topography) favourable to extreme fire behaviour<br>> Assessment of fire likelihood and intensity at operational level requires high-resolution spatial and temporal data<br>> Increase the accuracy of wildfire simulations by integrating data on fuel characteristics and fire ignition<br>> Improve fire model prediction capacity in a changing context<br>> Develop innovative approaches (e.g. LiDAR) for fuel modelling and mapping |
| Fire ecology | > Limited knowledge on future ecosystems' responses to changing climate, fire and land-use conditions within and beyond fire prone areas prevents efficient ecosystem-based management | > Incorporate ecology principles into landscape planning and fire management plans more actively, distinguishing between fire dependent and fire sensitive ecosystems<br>> Develop a shared view of priorities for natural stakes (e.g. map of soil erosion risk) | > Assessment of the variability of species' regeneration niche across the distribution range<br>> Need to understand ecosystems' vulnerability and potential to adapt to changes in climate and fire regime<br>> Identify thresholds of change and tipping points in ecosystem regeneration, taking into account climate trends and past land-use/management history |
| Fire spatial and temporal patterns | > The lack of central databases with harmonised information on single fire events (e.g. data on fire perimeters, loss and damage) limits research capacity | > Incorporate knowledge on how spatial and temporal fire patterns shape ecosystem resilience in landscape planning<br>> Integration of multiple disturbance processes into forest dynamic models for decision support | > Analysis of historical spatio-temporal characteristics of fires is needed to understand the trends in fire regimes and associated risk factors<br>> Development of methods to map and explain the variations in fire severity during a fire event would allow for better impact assessment and identification of restoration needs<br>> Further research is needed on the socioeconomic drivers of fire ignition |
| Social aspects | > Limited understanding of the influence of socioeconomic aspects on fire risk<br>> Need to assess the various population responses to particular fire policies<br>> Perceptions of fire risk and fire use are often in conflict among social groups, which prevents successful community-based integrated fire management | > Participatory planning and opinion pools can be useful methods to evaluate the general public's acceptance of a given fire management policy in different regions<br>> Educational and awareness campaigns explaining the social, environmental and economic benefits of a specific management approach (and its associated risks) can foster its successful implementation | > Understanding the interaction between socioeconomic, ecological and climate factors in determining the vulnerability of communities to extreme wildfire events<br>> Assessing how policies and management decisions impact fire activity, especially in the WUI<br>> Identification of adaptation and development pathways which favour fire resilient landscapes<br>> Understanding how social values and attitudes of vulnerable groups in highly hazardous areas can be addressed by policies |
| Climate change | > Applicability of fire models is limited due to uncertainties in climate projections and spatial and temporal resolution issues | > Projections of future changes in fire danger can be used to design adaptation plans to mitigate the impact of climate change on forest fires<br>> Adaptation needs can already be assessed for the next few decades | > Fire risk models based on climate scenarios need to incorporate other factors such as landscape fragmentation, spatial distribution of ignition and suppression capacities to make them more realistic.<br>> Ecosystem response to fire under extreme meteorological conditions is not well known. |

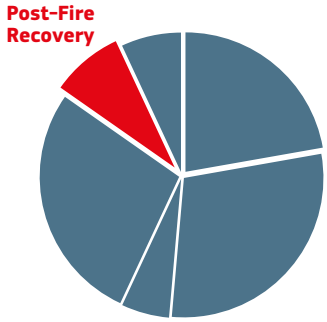



| | Barriers | Incentives | Research needs |
|---|---|---|---|
| Fire meteorology and fire danger rating | > Need for context-specific analyses of the weather/ climate influence on future fire regimes | > Development of long-term weather forecast (including seasonal forecast) to anticipate seasonal fire severity and guide strategic fire prevention activities<br>> Fire danger forecasting should consider ecosystem functioning to design adaptation strategies | > The relatively new phenomenon of large, very intense fires in many regions has created an urgent need for new knowledge on how they are generated, what their consequences and costs (financial, social and environmental) are and what the required mix of firefighting approaches is |
| Fuel management | > Limited uptake of scientific knowledge by policy and management actors to address fuel management under future climate/land-use scenarios<br>> Lack of guidance for fuel-management protocols at the EU level, including the use of prescribed burning<br>> Use of fire as a management tool is limited because of liability and casualty risks and little tolerance for management errors | > Create financial incentives to encourage 'fire safe' development in WUI/RUI areas at risk<br>> Promotion of residual forestry biomass exploitation through policy incentives targeted at private owners (e.g. markets for forest biomass residues and other low-value forest products)<br>> Foster public support for proactive use of prescribed fires to optimise biomass reduction | > Fire risk indices need to be harmonised and take into account the specificities of EU regions<br>> New approaches for long-term biomass management should be developed, taking into account historical land uses and fire regimes<br>> More research is needed on the effects of prescribed burning on forest ecosystems in order to improve operational effectiveness<br>> New tools based on cost–benefit analyses should be developed for the evaluation of fire prevention practices, including the use of biomass for energy.<br>> Develop 3D fire models to test improved design of vegetation treatments on fuel breaks |
| Preparedness | > Lack of involvement of local stakeholders in prevention activities<br>> Limited awareness of forest fire risk among vulnerable groups<br>> Cooperative solutions to improve preparedness are hindered by cultural, institutional and legislative issues | > Strengthening the European dimension of cooperative solutions between management agencies at the national level and between regions and countries | > Need to improve methods for informing the general public about the causes and impacts (financial, social and environmental) of extreme wildfire events and which prevention and suppression resources are needed<br>> Need to better understand the effectiveness of public warning systems<br>> Enhance cooperation and coordination between Member States in developing common wildfire training systems through the Union Civil Protection Mechanism |
| Wildland–urban interface | > Barriers lie in the understanding by national/ local agencies and acceptance by the general public of new fire management approaches<br>> Lack of adequate regulations on urban development planning in interface areas | > Promote education and training on wildfire risk in WUI areas to local communities<br>> Better communication on science-based recommendations for disaster-risk management in the WUI to support management actions<br>> Foster the involvement of local communities in the design and planning of prevention actions<br>> Adapt safety rules regarding building materials | > Improve knowledge on wildfire occurrence and behaviour in WUI areas, in particular with respect to land-use fragmentation and climate change<br>> Develop guidance on the use of fire resistant materials for housing construction in the WUI<br>> Develop innovative firefighting and safety techniques at the WUI<br>> Provide guidance for best prevention and emergency management<br>> Need to assess the effects of improved buffer zone design on mitigating fire impact on assets |




**Land, aerial and space detection**

| Barriers | Incentives | Research needs |
|---|---|---|
| > Technology transfer to practitioners is limited due to the cost of investment<br>> The rate of false alarms in the detection of fire ignition is high<br>> Space detection does not currently meet the requirements for the rapid detection of fires; in addition the use of drones has limitations | > Extend the use of land, aerial and space detection to areas of interest (e.g. cultural heritage sites)<br>> Develop multi-agency investigation teams to improve knowledge of ignition causes | > Need to better understand the causes of the high rate of false alarms by detection systems<br>> Improve the reliability of networks of fire detection systems<br>> Define standards for the operational requirements of fire detection systems (e.g. minimum size of the fire detected, delay time, false alarm rate) |



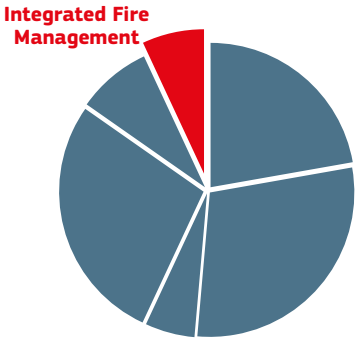

**Damage and loss assessment**

| Barriers | Incentives | Research needs |
|---|---|---|
| > Limited translation of remote-sensing information to the planning of prevention and post-fire management practices<br>> Lack of incorporation of fire ecology principles in conservation and land-management policies | > Use of vegetation phenology indicators to monitor post-fire recovery of ecosystems<br>> Promote testing/validation of new remote-sensing tools and methods by forest managers<br>> Encourage land planners to use satellite-based sources of information<br>> Make forest managers aware of the usefulness of 3D damage assessment tools, damage severity indices and vegetation recovery maps | > Identify thresholds below which plant-community integrity cannot be sustained<br>> Improve the understanding of ecosystems' vulnerability to various fire recurrences and intensities<br>> Need to incorporate direct environmental losses (e.g. wood, forest area, infrastructures) and indirect losses (e.g. air quality, biodiversity, etc.) into the economic assessment of fire damage |

**Restoration**

| Barriers | Incentives | Research needs |
|---|---|---|
| > Current lack of monitoring and evaluation of post-fire restoration projects<br>> Limited information on the potential of post-fire management actions to avoid secondary damage in the short term<br>> Guidance for efficient and context-specific restoration planning and design in fire prone areas | > Investing in the protection of fire sensitive habitats from permanent degradation and in the restoration of forestry potential after fires<br>> Pilot and demonstration projects would help the adoption of available scientific innovations<br>> Stimulate the incorporation of new restoration treatments into management protocols | > Need to identify the role of ecological processes, e.g. germination, involved in post-fire community recovery<br>> Improve knowledge on species' acclimation capacity to new fire regimes, increased drought and climate change<br>> Incorporate the landscape dimension into post-fire restoration projects with a view to improving biodiversity and producing more fire resilient landscapes |


| | Barriers | Incentives | Research needs |
|---|---|---|---|
| **Firefighting techniques** | > Applicability of new firefighting techniques and equipment requires further testing and validation<br>> The level of acceptance and integration of new methods and tools varies between civil-protection stakeholders<br>> The market for firefighting products and associated training is underdeveloped and not easily accessible<br>> Safety laws do not systematically consider new firefighting products and techniques due to liability issues, for example | > Provide better guidance on the application and risks/benefits of firefighting techniques (e.g. use of suppression fire)<br>> Improve the allocation of firefighting resources and decision-making capacities using reliable estimates of firefighting effectiveness<br>> Generalise post-fire reviews to feed a lessons-learned information system | > Need to evaluate firefighting techniques/ equipment effectiveness in real conditions<br>> Improve knowledge on the temperature resistance of firefighting materials<br>> Need for coherence between aircraft and drone navigation and aeronautic legislation |
| **Fire safety** | > Low degree of acceptance of new proposals for evacuation strategies or safety measures in general<br>> Negative perception of forest fires and public objections to particular land-management practices (e.g. prescribed burning)<br>> Outdated protocols for fire safety in relation to risks emerging from extreme wildfire events | > Monitor the progress and evaluate the efficiency of safety measures<br>> Encourage the exchange of good practices on fire prevention, fire safety and training<br>> Make substantial efforts to educate the public about the inevitability of fire and its ecological benefits | > Research should address the long-lasting social and health impacts of forest fires to better educate vulnerable groups, including firefighters<br>> Need for updated guidelines or procedures on how citizens should equip themselves for emergencies involving extreme fire events |
| **Technological tools** | > Lack of involvement of local stakeholders in prevention activities<br>> Limited awareness of forest fire risk among vulnerable groups<br>> Cooperative solutions to improve preparedness are hindered by cultural, institutional and legislative issues | > Demonstrate the added value and applicability of the tools, e.g. simulation tools for training fire managers<br>> Promote planning and decision-making tools that are tailored to particular safety, prevention and firefighting needs<br>> Improve the transferability and uptake of tools to ensure up-to-date and harmonised guidance for operations<br>> Support the efforts of first-responder teams in the management of multi-casualty incidents | > Improve predictions of wildfire propagation and real-time risk analysis by considering the variability of wind speed and direction, humidity and fuel moisture influencing weather forecasts<br>> Improve accuracy in fire detection systems and usability of the tools by crisis managers by using multispectral images with multiple time series<br>> Demonstrate the applicability and multiple benefits of unmanned aerial vehicles (UAVs) |




## Integrated fire management

| Barriers | Incentives | Research needs |
|---|---|---|
| > Government fire agencies often focus solely on fire protection without considering ecological and social concepts in designing fire management strategies<br>> Lack of social and political involvement in the design and implementation of effective risk governance<br>> Limited social acceptance of new fire and land management practices calls for better education about fire behaviour and fire ecology<br>> Low profitability of wood-based products and fragmented ownership prevent sustainable forest management by private owners | > Develop new awareness-raising methods to overcome attitude and behavioural barriers<br>> Further develop the multifunctionality of forests by supporting forests' economic, recreational and amenity value chains<br>> Promote wildfire protection strategies that deal effectively with both beneficial fires and detrimental fires<br>> Empower local communities with the incentives, tools, information and skills to recognise the benefits of integrated fire management and to apply it<br>> Promote incentive programmes for sustainable fuel management such as payment for ecological services<br>> Foster a multi-risk approach in forest management to account for other biotic and abiotic disturbances (e.g. insects, wind storms, droughts) | > Improve understanding on how an ecosystem responds positively or negatively to fire<br>> Document and promote the beneficial aspects of prescribed fire use and develop the knowledge, capacity and technology to apply fire safely where needed<br>> Develop and implement adequate and cost-effective detection, prediction and response tools and procedures to respond to extreme wildfire events<br>> Develop flexible fire management plans and policies that account for the differences in regional contexts across the EU |

## ANNEX II FUTURE RESEARCH AND INNOVATION PROGRAMMING

Under Horizon 2020, the 'programmatic' responsibilities on 'forest fires' are shared between SC2 (Section 2.1.4 in the specific programme) and SC5 (Section 5.2.3), with the latter more from a monitoring and risk-management perspective and the former more from an ecosystem-resilience and restoration perspective.

For the last programming cycle under Horizon 2020, both SC2 and SC5 have earmarked funding for 2020 for relevant topics, as follows:

- SC2: LC-RUR-11-2019-2020: Sustainable wood value chains, B. [2020] resilient forest systems,
- SC5: LC-CLA-15-2020: Forest fire risk reduction: towards an integrated fire management approach in the E.U.

A sharp gradient exists from southern Europe to northern Europe, in terms of contributing and causing factors, fire frequency and area burned, and fire behaviour. Nevertheless, there is growing evidence to suggest that changes in species' niche dynamics, due to climate change and anthropogenic intervention, have implications for the expansion of the fire prone area towards forested areas which have not previously been known to be susceptible to forest fires. This will become one of the major challenges of sustainable forest management in future decades, especially in light of efforts to mitigate greenhouse-gas emissions through forests' sequestration of carbon. Implications for forest-adaptation practices will be instrumental in reducing fire proneness.

With this background in mind, it can be seen that tackling forest fires effectively will require a joint effort at regional, national and EU levels, and by employing a variety of policies and funding sources, going well beyond R & I policy. Future R & I will contribute to generating the knowledge, tools, capacity and guidance required to underpin an integrated fire management strategy that promotes holistic landscape and forest management and considers interaction among all phases of the wildfire management process. The promotion of the concept of integrated fire management and its applications by Member States may be the way forward with a view to tackling the global EU wildfire problem.

## ANNEX III LIST OF PROJECTS MENTIONED

| Project acronym | Financial instrument | Project name and websites |
|---|---|---|
| **AF3** | FP7 | Advanced forest firefighting<br>> af3project.eu/af3/ |
| **ANSFR** | Civil Protection | Accidental, natural and social fire risk<br>> http://ec.europa.eu/echo/files/civil_protection/civil/prote/pdfdocs/2008_ansfr_recommendations_en.pdf (recommendations)<br>> http://ec.europa.eu/echo/files/civil_protection/civil/prote/pdfdocs/ansfr.pdf (presentation) |
| **Arcfuel** | LIFE | Mediterranean fuel maps geodatabase for wildland and forest fire safety<br>> http://www.auth.gr/sites/default/files/press/best_life_v.2.0.pdf (award) |
| **BIOENERGY & FIRE PREV** | LIFE | Contribution of forest biomass generated in the prevention of forest fires in the EU energy strategy<br>> http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=3653&docType=pdf (description) |
| **DECATASTROPHIZE** | Civil Protection | Use of SDSS and MCDA to prepare for disasters or plan for multiple hazards<br>> http://decatastrophize.eu/ |
| **DEMORGEST** | LIFE | Cost-efficient integration of megafire prevention into forest management in the Mediterranean<br>> http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=4818 (description)<br>> http://cpf.gencat.cat/en/cpf_03_linies_actuacio/cpf_transferencia_coneixement/cpf_projectes_europeus/cpf_life_demorgest/ (website) |

| Project acronym | Financial instrument | Project name and websites |
|---|---|---|
| **EARLYHUMANIMPACT** | FP7 | How long have human activities been affecting the climate system?<br>> www.earlyhumanimpact.eu<br>> https://cordis.europa.eu/result/rcn/202674_en.html (final report) |
| **EFIRECOM** | Civil Protection | Efficient fire risk communication for resilient societies<br>> http://efirecom.ctfc.cat/ |
| **ENERBIOSCRUB** | LIFE | Sustainable management of shrub formations for energy purposes<br>> http://enerbioscrub.ciemat.es/ |
| **FILE** | FP7 | Fire interactions with life on earth<br>> https://cordis.europa.eu/result/rcn/143542_en.html<br>(CORDIS final report summary – Marie Curie project)<br>> https://cordis.europa.eu/result/rcn/151152_en.html (Result in Brief)<br>> https://wildfire-lab.com/ (prof. Claire M. Belcher) |
| **FIREPARADOX** | FP6 | An innovative approach of integrated wildland fire management regulating the wildfire problem by the wise use of fire: solving the fire paradox<br>> http://www.fireparadox.org/ |
| **FIREFFICIENT** | Civil Protection | Operational tools for improving efficiency in wildfire risk reduction in EU landscapes<br>> http://firefficient.ctfc.cat/ |
| **FIRELI** | FP7 | Fire-retardant line hoses for forestry fire fighting applications<br>> https://cordis.europa.eu/result/rcn/92558_en.html (CORDIS Result in brief) |
| **FIRELIFE** | LIFE | Hungarian forest fire prevention and training programme<br>> http://erdotuz.hu/firelife-project/ |
| **FIREROB** | FP7 | Autonomous firefighting robotic vehicle<br>> https://www.asme.org/engineering-topics/articles/automotive/robotic-firefighting-vehicles<br>> http://www.euronews.com/2011/01/11/the-robot-firefighter (EURONEWS)<br>> https://cordis.europa.eu/result/rcn/92481_en.html (CORDIS Result in Brief)<br>> https://cordis.europa.eu/result/rcn/58215_en.html (final report summary) |
| **FIRESCAPE** | H2020 | Firescape genomics: predicting plant responses to changing fire regimes<br>> https://cordis.europa.eu/project/rcn/208889_en.html (individual fellowship) |
| **FIRESENSE** | FP7 | Fire detection and management through a multi-sensor network for the protection of cultural heritage areas from the risk of fire and extreme weather conditions<br>> http://netlab.boun.edu.tr/firesense/#<br>> https://cordis.europa.eu/result/rcn/92810_en.html (result in Brief)<br>> https://cordis.europa.eu/result/rcn/143051_en.html (final report summary) |
| **FORESTERRA** | FP7 | Enhancing forest research in the Mediterranean through improved coordination and integration<br>> http://www.foresterra.eu/ |
| **FOSEPOGA** | Civil Protection | Training to manage emergencies in the cross-bordering areas of Galicia and north of Portugal<br>> https://ec.europa.eu/echo/files/civil_protection/civil/prote/pdfdocs/calls_2007_projects/fosepoga.pdf (presentation) |
| **FUME** | FP7 | Forest fires under climate, social and economic changes in Europe, the Mediterranean and other fire affected areas of the world<br>> http://fumeproject.uclm.es/ |
| **GRADIENT** | H2020 | Understanding fire, weather and land-cover interaction from long-term terrestrial observations and satellite data in a north to south transect in Europe and north Africa<br>> https://www.wsl.ch/en/projects/fire-weather-and-land-cover-interactions.html<br>MARIE SKŁODOWSKA-CURIE ACTIONS – Marie Curie Individual Fellowship project – H2020-MSCA-IF-2015 |
| **HESFIRE** | H2020 | Drivers and projections of global fire activity and intensity under future climate and societal changes<br>> https://cordis.europa.eu/project/rcn/195867_en.html<br>MSCA-IF-2014-EF – Marie Skłodowska-Curie Individual Fellowships (IF-EF) |
| **HOLISTIC** | Instrument for Pre-Accession Assistance | Adriatic holistic forest fire protection<br>> http://www.adriaholistic.eu/ |

| Project acronym | Financial instrument | Project name and websites |
|---|---|---|
| **INTEGRAL** | FP7 | Future-oriented integrated management of European forest landscapes<br>> http://capsis.cirad.fr/capsis/_media/documentation/reports/14_orazio2014-03_integral_caqsis.v3.pdf (presentation) |
| **MIRTO** | Civil Protection | Minimising forest fires risks for tourists<br>> http://ec.europa.eu/echo/funding-evaluations/financing-civil-protection-europe/selected-projects/minimizing-forest fires_en |
| **MONTSERRAT** | LIFE | Integrated silvopastoral management plan: An innovative tool to preserve biodiversity and prevent wildfires<br>> http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=5112 |
| **MOTIVE** | FP7 | Models for adaptive forest management<br>> https://www.wsl.ch/lud/motive/ |
| **ODS3F** | Civil Protection | Observation and detection systems for forest fire management<br>> http://ec.europa.eu/echo/funding-evaluations/financing-civil-protection-europe/selected-projects/observation-and-detection_en |
| **PESETA II** | JRC | Projection of the economic impact of climate change in sectors of the European Union based on bottom-up analysis<br>> https://ec.europa.eu/jrc/en/peseta |
| **PHOENIX** | COST action | Post-fire forest management in southern Europe<br>> http://uaeco.edu.gr/cost/ |
| **PREDICATE** | Civil Protection | Preventing disasters by capitalising on unmanned aerial systems technology<br>> http://www.kios.ucy.ac.cy/research/research-projects/completed/294-preventing-disasters-by-capitalizing-on-unmanned-aerial-systems-technology.html |
| **PREFER** | FP7 | Space-based information support for prevention and recovery of forest fire emergencies in the Mediterranean area<br>> http://www.prefer-copernicus.eu/ |
| **PROMYLIFE** | Civil Protection | How to better protect my life in major emergencies?<br>> http://ec.europa.eu/echo/files/civil_protection/civil/prote/pdfdocs/calls_2007_projects/promylife.pdf (presentation) |
| **SCODEV** | H2020 | Scooping device for aerial forest fire suppressant<br>> http://www.scodev.eu/ |
| **SMART FIRE BARRIER** | H2020 | Innovative forest fire prevention infrastructure for residential areas, forestry and critical infrastructures<br>> http://www.pyro.es/ (SME project)<br>> https://cordis.europa.eu/result/rcn/188569_en.html (result in brief) |
| **SPITFIRE** | Civil Protection | Spanish-Portuguese meteorological information system for transboundary operations in forest fires<br>> http://ec.europa.eu/echo/funding-evaluations/financing-civil-protection-europe/selected-projects/spanish-portuguese_en |
| **WUIWATCH** | Civil Protection | Wildland–urban interface forest fire risk observatory and interest group in Europe<br>> https://wuiwatch.org/ |

## Getting in touch with the EU

### IN PERSON

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*Research and Innovation policy*

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