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Towards wildfire risk reduction goals and targets for Europe – Opportunities and challenges

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ABSTRACT

The impact of wildfires is increasing worldwide. The root causes of these effects are manifold, encompassing among others climate change and the accumulation of fuels and increasing settlements in wildland-urban interfaces (WUI). Reports and initiatives to better understand and govern these developments have been launched and call for more integrated approaches to wildfire risk management, including the use of targets or Key Performance Indicators (KPIs).

However, despite some examples such as Portugal, wildfire risk management targets are still mainly lacking in Europe. This is surprising since they find wider application in the U.S. and are also more widely applied for flooding in Europe.

This perspective hence takes a closer look at the use of targets in reducing disaster risk for different hazards worldwide and reflects about the opportunities and challenges for wildfire risk reduction targets for Europe. It concludes with some suggestions for the application of wildfire risk reduction targets for Europe.

1. Introduction

Wildfires are evolving globally in various aspects, including frequency, intensity, and behaviour, making them more destructive

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than previously seen. The timing and locations of wildfires are shifting, resulting in extended fire seasons in many regions, particularly in Europe, as well as new wildfire dynamics in areas that were traditionally not prone to fire (Galizia et al. 2023). Burton et al. (2024) show that climate change caused an increase in global burned area while specifically also the magnitude of extreme events (≥99.99th percentile) is increasing (Cunningham et al. 2024). The increase in extreme wildfire events gave rise to a number of reports and initiatives trying to enhance wildfire risk management (e.g UNEP (2022) or OECD (2023)).

The UNEP report points out Portugal as a good example for governing wildfire risk which was a main driver behind the Landscape Fire Governance Framework[1] (AGIF 2023). The guidance document for developing integrated landscape fire governance approaches was endorsed by many countries internationally. It suggests that adaptive management strategies should develop and communicate clear targets. Likewise, the OECD report refers to examples on the use of targets e.g. in relation to the design of wildfire resilient infrastructures (p. 97).

Under the European Green Deal, a policy initiative aiming to transform European economy, ensuring no net emissions of greenhouse gases by 2050 (European Commission, n.a.), about 60 Mio. € were made available to respond to extreme wildfire events by funding research and innovation projects.[2] The call for proposals for the wildfire risk management projects also suggested a set of targets for 2030.[3]

2. Opportunities of using targets in governing wildfire risk

2.1. The use of targets in managing disaster risk

The use of targets in governance processes is an established tool at different scales which implies the engagement of multiple stakeholders. They are usually specifying and sometimes quantifying strategic goals. At the international level, most prominent examples are the Sustainable Development Goals (SDGs) or the goal to "limit the temperature increase to 1.5 °C" under the Paris Agreement. In governance processes, targets are usually specifying high-level goals. In the case of the SDGs for example, 169 targets have been agreed upon to guide the implementation of the 17 goals (Biermann et al., 2017). Targets are thereby used "to monitor performance, evaluate progress and […] hold service providers and other responsible agents accountable." (Fukuda-Parr 2013, p. 3).

Overall, targets guide the effectiveness of policies and strategies as defined by goals (Behn 2003) by clearly articulating specific objectives and establishing a shared understanding among stakeholders. Targets can not only support motivation and collaboration (Simmonds et al. 2020) but allow for systematic measurement of progress and success as well as for periodic reassessment and adjustment of strategies (Maron et al. 2021). Targets may be more contested than high-level goals such as "Zero Hunger" (SDG 1) as they relate to the actual ways of implementation and respective responsibilities. Likewise, targets are related to technical aspects of stakeholder engagement and measurability as depicted later-on.

For the disaster risk management context, it was suggested to "establish clear, numerical targets at a global scale to act as eye-catching, awareness-raising components." (Mitchell et al. 2014). In line with this, the Sendai Framework for Disaster Risk Reduction has developed seven global goals such as to substantially reduce the number of affected people globally by 2030 (UNDRR 2015). They are paired with priorities for action and a monitoring process. A set of 38 indicators are used to track progress (UNDRR, n.a.).

2.2. Hazard specific application of disaster risk targets

A closer look at the use of targets in hazard specific disaster risk management shows that their application in Wildfire Risk Management (WFRM) is an increasingly relevant but still relatively nascent area of research, especially when compared to other hazard-related fields. Since 2012, the number of publications on the use of targets in WFRM shows a moderate but accelerating growth trajectory (see Fig. 1).[4]

In comparison, the number of publications on the use of targets in flood risk management has been growing steadily since the early 2000 s and the overall growth rate remains strong and continues to accelerate. Both the total volume of publications and the rate of increase in flood-related targeting research exceed those observed in the WFRM field, highlighting a more established and active research landscape for flood risk management.

Fig. 2 reveals that the vast majority of publications on WFRM targets originate from the United States. In contrast, EU Member

[1] The Landscape Fire Governance Framework ("framework") is a legally non-binding, voluntary, set of guiding principles, goals, and governance proposals, for adjusting strategies, policies, and landscape fire management at a global level, answering to global challenges. It was presented at the International Wildland Fire Conference in Portugal in 2023 and is internationally endorsed by many countries.

[2] The projects FIRE-RES, SILVANUS, TREEADS, and Firelogue can be found in the CORDIS Data base (H2020 | CORDIS | European Commission).

[3] https://cordis.europa.eu/programme/id/H2020_LC-GD-1-1-2020 (13.05.2023).

[4] A bibliometric analysis was conducted by applying the KATI (Knowledge Analytics for Technology & Innovation) data analytics platform developed by Fraunhofer INT. It leverages bibliometric data from the Web of Science (approximately 73 million publication records as of March 2023) and enables interactive visualizations and trend identification across large datasets. The bibliometric analysis was conducted using KATI3. The datasets were generated using hazard-specific topic search queries. For Wildfire Risk Management (WFRM), the query was: *"wildfire AND target AND (policy OR governance OR strategy)"; for Flood Risk Management (FRM), the query was: *"flood AND target AND (policy OR governance OR strategy)".Data retrieved by Fraunhofer KATI from Web of Science, the dataset and information on the search queries can be found here in Zenodo.

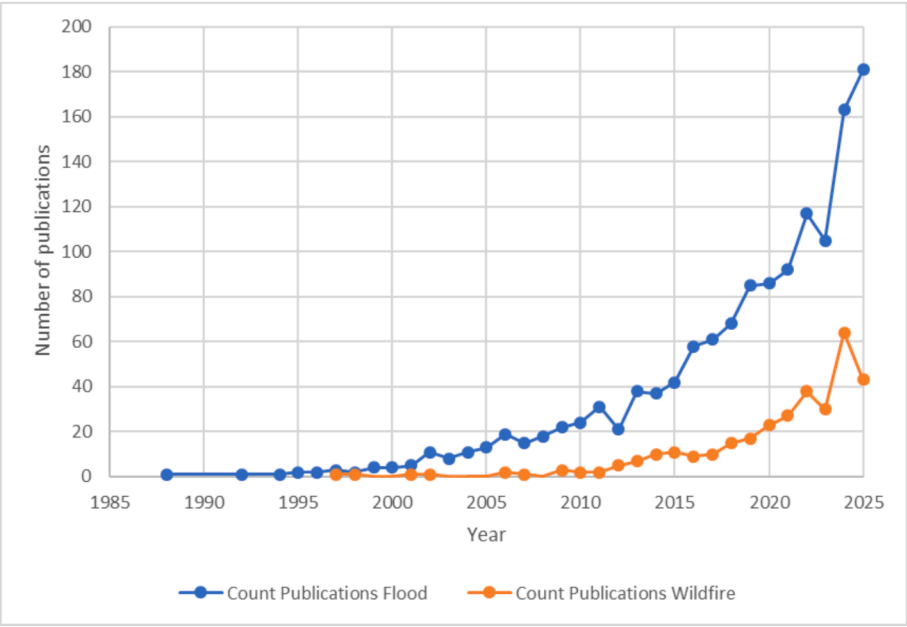

Fig. 1. Number of Annual Publications on the use of targets in WFRM & flood risk management; data for 2025 is not yet complete.

States exhibit comparatively lower levels of activity. Among them, Spain (n = 30) and Portugal (n = 17) stand out with the highest publication output. As shown in Fig. 3, the United States not only demonstrate a higher overall volume of publications but also entered the field significantly earlier. While Spain and Portugal show growing engagement in recent years, the temporal and quantitative gap indicates a lag in European contributions to the development of goals and targets in WFRM.

In comparison, the publication dynamics in the field of flood-related targets reveal a more balanced international distribution (see Fig. 2). While the United States dominates publication output on WFRM targets, this is not the case in the context of flood risk management. Here, the combined publication activity of EU member states (n = 507) surpasses that of the United States (n = 314).

This bibliometric analysis confirms that the concept of targets is well established in hazard management, particularly in the field of flood risk management, where research activity is both substantial and internationally balanced. One example of applying targets to flood risk management from Europe is the UK which identified a number of targets and associated outcome measures in their flood risk reduction strategy, e.g. with respect to government investments in the flood and coastal erosion risk management programme or the number of households with increased standard of protection against flooding or coastal erosion risk. (Defra 2005).

In contrast, the application of targets in WFRM is still at an earlier stage of development. The analysis highlights that EU member states, in particular, have room to strengthen their engagement and align more closely with global developments in this emerging area. An international example is e.g. the report on outcome-based performance measures from the U.S. by Schultz et al. (2022). For Europe, Portugal is a good example of applying targets. The National Action Plan (NAP) approved by the Council of Ministers in 2021 implements the strategic objectives defined in the National Plan for Integrated Management of Rural Fires (AGIF, n.a.a). It proposed several targets along the lines of objectives such as “Enhancing rural areas”, “Caring for rural areas” or “Change behaviour” (AGIF, 2024):

- The loss of human life attributable to fire, although possible, is a rare phenomenon;
- The percentage of fires with more than 500 ha is below 0.3 % of total fires;
- The accumulated burnt area over the decade is less than 660.000 ha

3. Challenges in defining targets for managing wildfire risk and recommendations

The development of WFRM targets may be hampered by specific challenges which we depict in the following in order to suggest some options to advance the application of WFRM targets in Europe.

3.1. Multi-stakeholder engagement and the normative dimension of targets

Integrated WFRM depends on political, legal and cultural framework conditions, including the complex interplay of different stakeholders such as emergency management organisations, the scientific community, policy-making bodies as well as land management groups or environmental associations, media and society (Martín et al. 2022). All stakeholders bring along different mandates and objectives towards managing wildfire risk and measures that are considered right by one stakeholder may counteract the activities

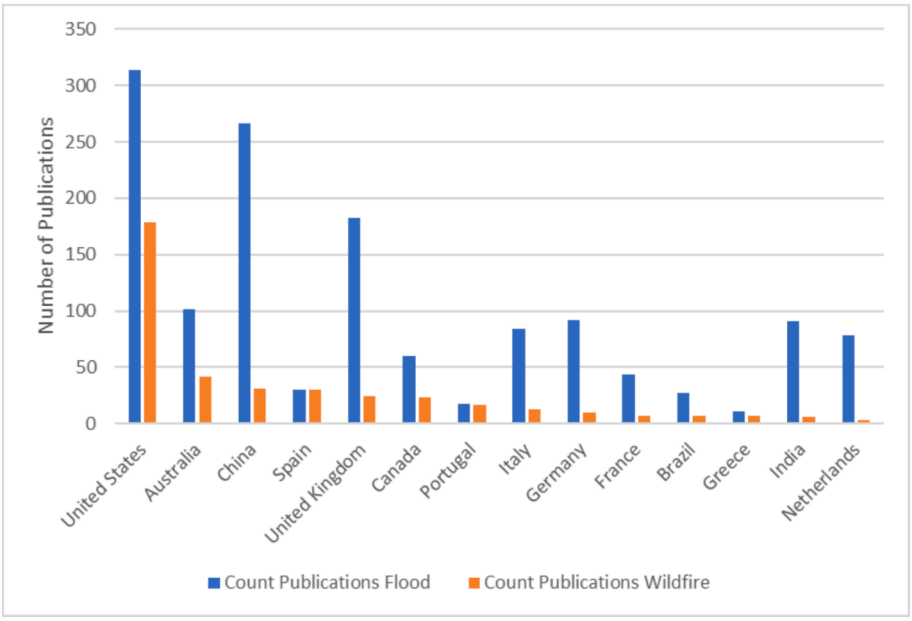

Fig. 2. Origin of Publications on WFRM and Flood targets.

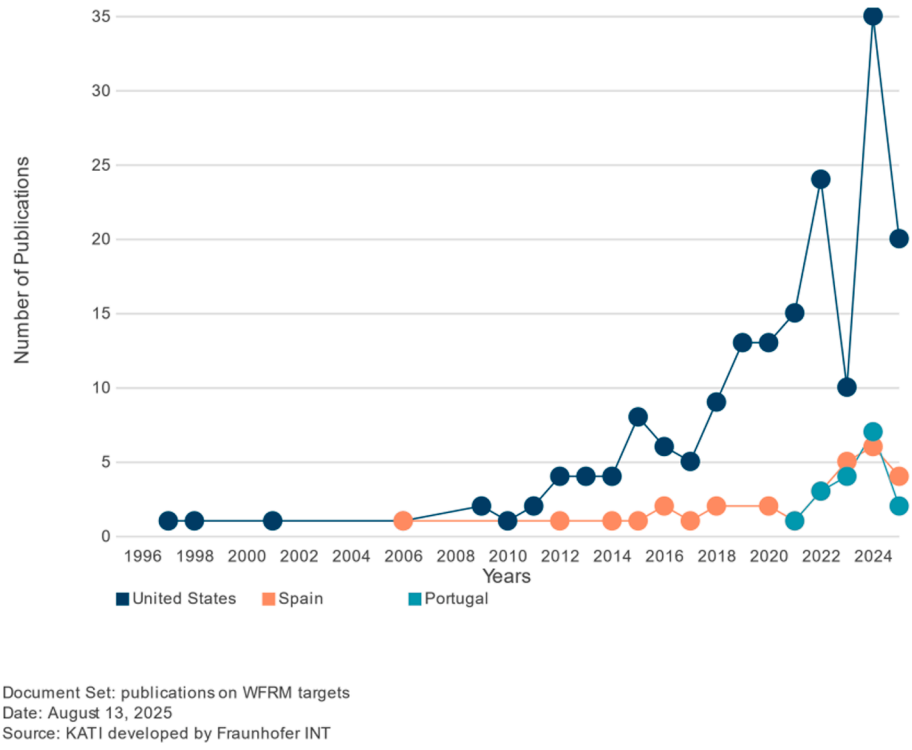

Fig. 3. Publication dynamics of the US, Spain and Portugal.

by another or be perceived as unjust in terms of responsibilities or costs related to them. This aspect is particularly pertinent in Europe with a densely populated area, comparatively small-sized land tenure, frequently very decentralised governance mechanisms and a subsequent high amount of different interest groups.

The engagement of multiple stakeholders is hence closely related to value systems and preferences of stakeholders, i.e. normative aspects of managing wildfire risk. What is prioritised or de-emphasised in different approaches to achieving targets has real, and often

differential consequences across societies, ecosystems, and governance processes. For example, targeting zero fatalities from wildfires is usually a set target that society aims to achieve. An opportunity to reduce firefighter fatalities can be to not intervene in certain (high intensity) fires or parts of them. Firefighting resources may be allocated where they will be most effective at protecting lives, not necessarily where property losses are most likely (Australasian Fire Authorities Council, 2005).

Another example of differential interests in managing wildfire risk are insurance coverage and related aspects of actual access to it (Lambrou et al. 2023, Collins and Bolin 2009) as insurance companies exclude certain areas from their coverage or request very high premiums (Buchter 2025). Insurance for (economically used) forest areas that includes wildfires is not yet widely available across Europe, notably not in wildfire-prone countries like Portugal, Italy and Greece, where the government tends to step in on an ad-hoc basis to support victims financially (Reuters 2024, Reuters 2018).

It is hence crucial to discuss *how* targets are to be achieved. Even the same target, as it is mediated across different actors and users, can be related to different expectations across social and professional settings (Fiore-Gartland and Neff 2015). Documenting, negotiating, and communicating these expectations are as important as the definition of the target, data gathering, and *meta*-data practices themselves for explaining and validating how they support the intended targets (Dourish and Gómez Cruz, 2018).

In the example of Portugal, an extensive analytical process on the systemic weaknesses and the development of a draft report was as followed by a complex consultation process involving public bodies and conducting technical plenary, bilateral and sectoral consultation meetings. The document was furthermore made available for public discussion for 60 days. “During this period, 73 information sessions were held from the north to the south of the country, attended by more than 2,000 people. A total of 115 written contributions were received, which made it possible to improve the documents put up for discussion and also to significantly improve the National Action Programme.” (AGIF, n.a.b).

Overall, the multitude of stakeholders in managing wildfire risk can be a challenge in defining and executing WFRM targets. In order to identify and engage the relevant actors, stakeholder analysis and mapping can be a useful approach to understand the actors in more detail and to develop networks more strategically at different scales. Wildfire stakeholder networks can vary across dimensions such as sectors, levels, and risk management phases (Vallim et al. 2023).

In the engagement process it can be useful to depict the stakeholder roles and interests and the implications of WFRM measures for them explicitly. Schinko et al. (2023) have proposed to apply a justice lens to understand the distribution of risk as well as aspects of procedural justice, i.e. who is actually considered in risk management processes can play a role in developing such approaches. Other examples of justice aspects that may relate to *restorative* justice in the sense of who has access to insurance mechanisms, who can benefit from structural adaptation funds, etc. Making use of the insurance example, the application of justice aspects raises a series of questions around what kinds of insurance are desirable and whether the coverage should be provided by private companies or the state.[5] Similarly, it suggests further considerations as to what losses should be covered.

Overall, such processes need to be embedded into broader analyses of policy coherence. Different policy fields are of relevance for wildfire risk management and in order to be effective, activities related to fields such as agriculture, forestry, civil protection, or land-use planning need to be aligned (Plana et al. 2024).

The example of Portugal offers an idea of how complex stakeholder engagement processes could be organised in Europe.

3.2. *Diversity of vegetation and climate characteristics*

Balancing the intricacies of climate, vegetation, land use (Gajendiran et al., 2024; Celis et al. 2023, Moreira et al. 2011), and historical fire data (Wang et al. 2024, Gomov et al. 2019; Wittkuhn and Hamilton 2010) is essential in crafting targets that are robust, context-specific, and responsive to the evolving wildfire landscape. Overall, the complex interplay between climate, vegetation density, and fire behaviour requires tailored fuel reduction strategies. Therefore, a nuanced understanding of the diverse challenges posed by varying vegetation characteristics, fire weather climatology, and ignition patterns are crucial for crafting effective wildfire management strategies.

Long-term climate patterns may thereby no longer serve as reliable indicators in the face of rapid climate change (Moritz et al. 2012). As climate conditions shift, fire regimes, including the fire sizes, frequencies, intensities, and seasonality of wildfires, are evolving in ways that render past fire data less relevant for predicting future risks (Sayedi et al. 2024; Vasques et al. 2023; Jones et al. 2022; Lake et al. 2017; Moritz et al. 2012; Fulé 2008). In regions where wildfires rarely occur or have been effectively suppressed for extended periods, historical data on fire behaviour and impacts may be scarce, unreliable, or non-existent (Hai et al. 2023, Doerr and Santín 2016; Taylor et al. 2013).

Consequently, the diversity of vegetation and climate characteristics across Europe requires for the localised development or adjustment of targets. More specifically, localised risk assessments making use of up-to-date fuel parameters and aspects of elements at risk including their vulnerability and coping capacity (Chuvieco et al. 2023) together with risk projections under different socio-economic and land-use development pathways should be considered (see e.g. Neidermeier et al., 2023 or Preinfalk and Handmer, 2024).

Guidance documents and peer learning between experts implementing such assessments and considering future scenarios for embedding them into multi-stakeholder collaborative contexts and translating them into land-use planning approaches could be useful

[5] Wild fire risk insurance isn’t necessarily an interesting market for insurers from a business perspective. Public insurance systems like the French or the Spanish ones may be an alternative example to consider in recommending larger insurance coverage while they also bring their own downsides such as state monopolies.

to facilitate such processes.

3.3. Assessing progress towards defined targets

Depending on the selection of goals and subsequent targets, usually a debate evolves around their measurability.[6] While targets may also be related to more qualitative criteria, all quantitative aspects are very much related to the matter of scale and data ownership.

In terms of scale, targets could be applied at the national level as in the case of Australia, the U.S. or Portugal. In the European context, they could also be applied at the supra-national level. For example, the development of targets at the European scale could be a useful approach to concerted action. However, little data is currently available at national and EU level to support scalar frameworks and some data may be available at local level only, such as prescribed burns or damaged buildings for example. At European scale, the European Forest Fire Information System (EFFIS) has been appointed to be in charge of the development and implementation of methods for the evaluation of forest fire danger and burned area mapping (European Parliament, 2006). As part of these regulations, the European Union Member States have the mandate to provide data to EFFIS such as first alert of a fire, total fire damaged area and its breakdown into forest and other wooded land and non-forested areas. EFFIS also publishes, on a yearly basis, a report on Forest Fires in Europe, Middle East and North Africa (San-Miguel-Ayanz et al., 2024) where the different countries, on a voluntary basis, provide a summary of the fires occurred in the previous years, their characteristics and impacts, and the fire prevention and extinction activities performed.

In terms of data ownership, much information that may be needed such as insurance coverage, for instance, is frequently only available through insurers, for purchase. Similarly, information on building damage can be retrieved in some countries within different ministries, in charge of different damage assessment programmes of private and public buildings, at post- or pre-disaster basis.

Finally, in order to assess any progress towards selected targets, the selection of a baseline is necessary. Only one year as a baseline may however not be sufficiently representative of fire occurrence due to statistical outliers. For this reason, using average or median values from a series of years could be more representative. The Portuguese National Strategy and Action Programme assumes 2019 as the zero year of implementation. (AGIF, n.a.b).

Some measures have been taken at European level to deal with the availability and more harmonised collection and use of data to allow for comparability across countries. A good example is the harmonized classification scheme of fire causes in the EU adopted for the European Fire Database of EFFIS (Camia et al., 2014). However, not all European countries have adopted this method. An enforcement mechanism for data collection and monitoring would hence be needed if targets should be developed and assessed at European level. While there is room for an enhanced data base and comparability, even the development of national strategies and respective national or regional targets and data sets might be a good starting point and could reflect the diversity of vegetation and climate characteristics as depicted above.

Depending on the unit of analysis, baseline data could be derived from time series (as proposed by Pettinari, 2022) or one (representative) year only, e.g. 2019 as in the case of Portugal.

4. Conclusion

The paper portrayed the use of targets in disaster risk management and the proposal of recent frameworks for their application to the WFRM context. While target-driven WFRM strategies have been developed in the U.S. and Australia already in 2014, this approach seems still underrepresented in Europe with some exceptions like Portugal. Consequently, we have discussed some opportunities and challenges related to a respective development and derive some suggestions in the following.

The Landscape Fire Governance framework proposes the development of targets as a means to developing integrated management strategies towards reducing wildfire risk. It builds on the example of Portugal that shows how goals and specifically targets can help to effectively reduce wildfire risk. Being created only after the devastating 2017 fires, the 2023 targets have been aligned with the expectations: no fire victims, an annual accumulated burned area below 66,000 ha and the percentage of fires covering more than 500 ha is less than 0.3 %. (AGIF, 2024). This example shows how strategies based on goals and targets can substantially reduce wildfire risk. However, in Europe, the application of targets for WFRM remains limited at the national scale and plays an even smaller role at the European scale.

In light of the increasing wildfire risk in Europe including the rising number of extreme events, we suggest the wider application of strategies including the use of goals and targets in line with the development of comprehensive risk reduction strategies and the installation of multi-stakeholder bodies to develop and execute them is necessary in Europe. This paper has depicted the opportunities as well as some related challenges.

We have shown that targets are much wider applied in flood risk management in Europe. A more detailed review with respect to potential lessons is hence suggested. The main driver in the development of targets in flood risk management can be supposed to be the Flood Directive (2007/60/EC) which requires the Member States to develop flood risk assessments and plans and to”establish appropriate objectives for the management of flood risks” (Art. 7 2.). A substantial increase in publications for Europe can be observed since 2003/2004. It is thereby important to stress that the Directive as a legal instrument requiring translation into national law, leaves

[6] For an example related to the SDGs see for example Mugellini et al. 2021.

room for countries to select relevant flood risk management objectives (see also e.g. Priest et al. 2016). The development of a comparable legislative framework might hence be a suitable way to enforce the development of goals and targets and to subsequently enhance wildfire risk management in Europe.

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CRediT authorship contribution statement

C. Berchtold: Conceptualization, Writing – original draft, Writing – review & editing. **K. Petersen:** Writing – original draft, Conceptualization. **M. Kaskara:** Writing – original draft, Conceptualization. **M.L. Pettinari:** Writing – original draft, Conceptualization. **J. Vinders:** Writing – original draft. **J. Schlierkamp:** Methodology, Data curation, Conceptualization. **N. Kalapodis:** Writing – original draft. **G. Sakkas:** Writing – original draft. **P. Brunet:** Writing – review & editing. **J. Soldatos:** Writing – review & editing, Writing – original draft. **A. Lazarou:** Writing – review & editing, Writing – original draft. **D. Casciano:** Writing – review & editing, Writing – original draft. **K. Chandramouli:** Writing – review & editing, Writing – original draft. **T. Deubelli:** Writing – review & editing, Writing – original draft. **A. Scolobig:** Writing – review & editing, Writing – original draft. **H. Silva:** Writing – review & editing, Writing – original draft. **E. Plana:** Writing – original draft. **M. Garofalo:** Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Claudia Berchtold reports financial support was provided by European Union. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data used was made openly available. The repository link is included in the paper.

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