A global outlook on increasing wildfire risk: Current policy situation and future pathways

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ABSTRACT

Aim: to understand how wildfire risk policies are designed to mitigate[1] the impacts of wildfires. Wildfires are a growing threat in many parts of the world, posing significant risks to human life, and the environment. In recent years, wildfires have increased, driven largely by climate change, human activity, and changes in land-use patterns. Wildfire risk adaptation and mitigation measures vary widely between countries and regions around the world. Therefore, it is essential to develop a comprehensive policy approach to mitigate wildfire risks and promote sustainable forest and land management practices. This article aims to provide insight into wildfire policies, implementation actions, and their effectiveness by describing wildfire policies centered mainly on exclusion and wildfire risk mitigation.

Methodology: the article examines existing wildfire-related policies and relevant literature based on 10 systematic factors. Further exploring how these policies can be enhanced to meet the challenges of the coming years for six European countries (Cyprus, France, Greece, Italy, Portugal, UK) as well as Australia, Canada, USA, and South Africa.

Results: The status quo, perceived strengths, weaknesses, and recommendations from key-informants were presented to enhance wildfire policies in each country.

Conclusions: The article analyses current wildfire policies in fire-prone countries, highlighting regional variations and the need for an integrated management strategy. It offers country-specific recommendations based on the

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[1] The goal of the analysis here is not to promote wildfire exclusion, but to reduce the likelihood of fire ignition and manage the growth and intensity of wildfire events.

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participants viewpoints, for coordinated efforts to mitigate wildfire risks and promote sustainable forest management.

1. Introduction

In recent years, significant attention has been drawn to the pressing issues of large-scale and intense wildfires, including their origins, causes, and repercussions (Abatzoglou and Williams, 2016; Franklin and Agee, 2003; Jolly et al., 2015; Pivello et al., 2021). These wildfires whether ignited by human or natural factors, have led to a transformation in fire regimes extending from local to global scales (Bilbao et al., 2020; Rego et al., 2021). Human activities, such as land management practices, play a significant role in altering natural fire regimes (Bowman et al., 2020; Hobbs et al., 2006). These alterations are considered as wildfire risk management, whereas activities deliberately and officially endorsed by government are recognized as policies (Hunter, 2008).

Given the increasing risk posed by climate change, forest ecosystem managers and policymakers face the challenge of developing effective fire prevention policies (Marques et al., 2011; Tymstra et al., 2020). Nevertheless, certain frequently overlooked factors at local and regional levels, including fire-related policies, have the potential to induce substantial shifts in fire intensity (Curt and Frejaville, 2018; Spadoni et al., 2023). While policy making is occasionally compelled by moments of urgency or crisis (Wenzelburger et al., 2019; Althaus et al., 2022), its potential should not be underestimated. It possesses the capacity to significantly mitigate long-term wildfire risks through various means, including the prevention of human-caused ignitions (Curt and Frejaville, 2018; Farkhondehmaal and Ghaffarzadegan, 2022), the suppression of fire spread (Fernandes and Botelho, 2003; Fernandes et al. 2021), and the strategic management of fuel to alter fire behavior (Graham et al., 2004). Hence, a well-crafted fire policy can exert an influence on fire characteristics akin to the impact of climate change itself (Wotton et al., 2017).

Thus, it is imperative to tailor fire policies to global changes, encompassing climate variations and socioeconomic considerations. This approach is pivotal for effective management of fire activity over the long term, as well as for mitigating the repercussions of fire on assets (Curt and Frejaville, 2018; Moreira et al., 2020; Ganteaume et al., 2021). This necessitates a shift in governmental investment toward fire management, emphasizing strategic planning and prevention (UN-REDD Programme). Recent instances of extreme fires in diverse regions, including Portugal (2017), Greece (2018), Australia (2019–2020), the Amazon rainforest (2019), Italy (2021), and France (2022) serves as alarming examples that trigger discussions on the reformulation of wildfire policies, as highlighted by Fernandes et al. (2017). However, these responses often manifest as reactive measures instead of proactive strategies aimed at mitigating risks prior to their occurrence (Montiel-Molina, 2013).

To gain a comprehensive understanding, this study aims to review current wildfire policies and legislations in 10 different countries. These countries include South Africa, the United States, Canada, Australia, the United Kingdom, Portugal, Italy, France, Greece, and Cyprus. The study takes a global-to-Europe outlook and pursues the following goals:

1 To analyze wildfire-related policies and legislation across geographical regions.
2 To document how wildfire policies are designed to manage wildfire risk by identifying the strengths and weaknesses.
3 To offer country-specific recommendations for enhancing wildfire policies.

2. Methodology

The paper focuses on analysing national wildfire policies. To achieve this, we embarked on a comprehensive review of policies, including both legally binding legislations and non-binding programs. Our analysis scheme, based on the works of Hall (1993); Howlett (2005); and Krott (2005), provided a consistent framework for evaluating wildfire related policies. We examined the key issues addressed, policy goals, policy instruments, and policy implementations by specifying the following questions:

- what are the issues addressed in the policy (identify the specific topics on wildfires)
- what are the policy goals (to identify how different countries deal with wildfire risk)
- what are the policy instruments (through legally binding legislations and non-binding programs and planning documents)
- how these policies are implemented (to assess how policy instruments dealing with wildfire risk in the country are applied).

This information provided valuable insights for making recommendations on enhancing the framework necessary to address the growing threat of extreme wildfires.

Data for this study were collected during the Pyrolife training and workshop[2] events held in April and June 2022. The workshop involved the use of questionnaire (Appendix A) designed by the corresponding author. Participants, including key-informants representing each of the countries under examination, contributed valuable information concerning prevailing policies, legislative status, the key decision-making actors, objectives, implemented actions, key monitoring indicators, prioritized issues, policy linkages, and allocated budget.

In our pursuit of a comprehensive policy analysis, the participants reviewed existing policy documents and relevant literature specific to their respective countries. Their valuable insights, born from meticulous examination, served to enrich and refine the dimensions of the analytical framework. This integrated approach was driven by the overarching objective of identifying both the perceived strengths and weaknesses inherent in the wildfire policies of each country.

This comprehensive analysis served as the foundation for developing informed recommendations aimed at enhancing the effectiveness of wildfire policies within individual nations. The systematic integration of investigative methodologies, including questionnaire, document analysis, and collaborative workshops, facilitated the thorough gathering and examination of relevant data. Additionally, the workshops not only provided a dynamic platform for advancing theoretical frameworks but also fostered in-depth discussions and shed light on previously unexplored areas for the improvement of current policies. Nevertheless, it is important to note that these findings offer a snapshot of the current situation and are constrained by the viewpoints expressed by the key-informants.

3. Results

3.1. Analysis of wildfire-related policies and legislation

3.1.1. South Africa

South Africa has a long history in the administration of wildfire

[2] Pyrolife – Making Change in Wildfire Management: Science Policy Interaction

management. A range of statutes pertaining to the Colonies of the Cape and Natal, as well as the Republics of the Orange Free State and Transvaal, were eventually consolidated in the Union Forest Act. However, starting from the mid-1940s, the management of veldfire (wildfires) became increasingly fragmented (Bridgett et al., 2003). Furthermore, changes in ecological concepts and a new focus on biodiversity as a central objective have resulted in modifications to fire policies. Practices that had been upheld for nearly 50 years have been challenged and, in some cases, replaced by alternative approaches (Bond and Archibald, 2003). Currently, various policies have a bearing on fire management in South Africa. The most significant among them are the Fire Brigade Services Act (Act 99 of 1987), which stipulates that district and local municipalities must establish firefighting service and define their responsibilities; the National Veld and Forest Fire Act (Act 101 of 1988), which aims to control wildfires, establishes the responsibilities and mandates of both public and private entities, and calls for the creation of Fire Protection Associations (FPAs), formed by landowners to manage the fire-risk in their territories; and the Disaster Management Act (Act 57 of 2002), which mandates provinces and districts to respond to such disasters, establishes the Disaster Management Center.

One of the initiatives grounded in the aforementioned legal framework is the Integrated Fire Management Handbook (2016), which outlines the steps for establishing an FPA and transforming it into a sustainable institution. By doing so, it shifts the focus towards the proactive practice of Integrated Fire Management (IFM), moving away from the reactive approach of suppressing wildfires (FynbosFire, 2016). "FPAs are not a firefighting body; instead, they serve as coordinating bodies for landowners and stakeholders to optimize the use of available resources" (UNOPS, 2016). Additionally, several other programs have been implemented to strengthen the legislation, such as the *Firewise Communities* model, which builds resilience in rural communities through awareness and community work (LANDWORKSTM, 2022); *Working on Fire,* launched as part of the South African Government's initiative to create jobs and alleviate poverty through the implementation of IFM practices (DFFE, 2022); and the *GEF FynbosFire* project, which has helped strengthen the IFM framework through initiatives such as collective planning, effective resource allocation, fostering relationships between multiple stakeholders, and developing policies. However, there is still a need for better integration of the laws that support the concept of IFM. Although there exists a National Veldfire Risk Assessment that serves policy purposes rather than operational ones (Forsyth et al., 2010). Distribution of the report for comment and further analysis of the current South African wildfire policy framework is recommended.

3.1.2. USA

The management of wildland fires is one of the responsibilities of the federal government of the United States. It oversees the management of public lands where controlled burns and wildfires occur, provides assistance in responding to wildfires, and conducts research to understand the impacts of fires (Federation of American Scientists, 2023). Recognizing the growing importance of this work, the Bipartisan Infrastructure Law has authorized the creation of the Wildland Fire Mitigation and Management Commission (Dabiri et al., 2023). The primary objective of this commission is to develop and present a comprehensive set of policy recommendations to Congress, with a specific focus on enhancing prevention, management, suppression, and recovery strategies for wildfires (USDA, 2023).

To effectively manage wildfire risk, the US federal government has implemented various policies, one of which is the National Cohesive Wildland Fire Management Strategy, also known as the "Cohesive Strategy". This policy emphasizes the importance of cooperation among federal, state, and local agencies, community involvement, and the use of science-based approaches to manage wildfires. In 2009, Congress passed the Federal Land Assistance, Management, and Enhancement Act (Federal Land Assistance, Management and Enhancement Act of 2009 (FLAME Act) (2022)), which mandated the development of the Cohesive Strategy for managing wildland fires across all lands in the United States. This act initiated a three-phased, intergovernmental planning and analysis process involving stakeholders and the public. As a result of this collaborative effort, a Cohesive Wildland Fire Strategy and National Action Plan were developed, with the participation of federal, state, local, and tribal governments, non-governmental partners, and public stakeholders, along with scientific analysis (WFLC, 2014). This act serves as a proactive response to large fires and includes measures for fire prevention and management.

The wildfire governance system in the U.S. encompasses a range of legally binding and non-binding policy directives, programs, budgets, and practices at the national, state, and local levels. One important framework within this system is the Cohesive Strategy, which consists of three policy goals. It recognizes the importance of adopting a regional and local approach to restore and manage fire-adapted ecosystems, build fire-adapted communities, and respond effectively to wildfires (The National Strategy, 2014). The Cohesive Strategy has become an effective policy for interagency wildfire management (Steelman, 2016). However, some scholars have raised concerns about the effectiveness of the governance system in the U.S. Changes in fire behavior pose a greater threat to houses in the Wildland-Urban Interface, leading to an increased emphasis on suppression response at the expense of prevention efforts to mitigate risk (Calkin et al., 2015; Fischer et al., 2016). In the U.S., one of the key drivers in the social-ecological system is funding priorities that favor suppression activities over prevention and preparedness activities (Steelman and Burke, 2007). There is a need for policies and practices that are better aligned with the social and ecological realities in the areas where wildfires are expected to be a problem (Steelman, 2016). Therefore, gaining a deeper understanding of how current policies and institutions correspond with the socio-ecological system can result in more sustainable, long-term alternatives to the wildfire issue.

3.1.3. Canada

Wildfire management agencies in Canada have evolved, remaining essentially as stand alone, single hazard wildfire control organizations (Tymstra et al., 2020). At the national level, emergency management falls under the responsibility of the federal government, which has established the Canadian Interagency Forest Fire Center (CIFFC) to coordinate fire management and response across the country (Tymstra et al., 2020). Each province and territory have its own wildfire management agency and policies. Besides, Indigenous communities in Canada face increased risks from wildfires (Nikolakis et al., 2020). These communities possess valuable local knowledge and practices related to fire management (Hoffman et al., 2022). Despite, various legal, political, and attitudinal barriers hinder the re-activation of Indigenous fire management which affects the wildfire management system in the country (Hoffman et al., 2022; Nikolakis et al., 2020). With the increasing frequency and intensity of wildfires in Canada, the wildfire season has also evolved. Recent unprecedent wildfires have surpassed the suppression capabilities, highlighting the urgent need for enhanced techniques and resource capacities to mitigate wildfire risk (Hoffman et al., 2022). The adoption of a risk-based approach to appropriate response is a direct result of devastating wildfires seasons, subsequent reviews, policy change recommendations, and recognition of the ecological role of wildfires as well as the need to control costs (Tymstra et al., 2020). The Wildfires Act serves as the primary federal legislation governing forest fire management on federal lands, providing guidelines for fire regulation, penalties for non-compliance, and authorization for the use of fire as a forest management tool (Tymstra et al., 2020). To effectively facilitate response to all emergencies, the Canadian government has adopted an all-hazard approach to manage natural and human-caused hazards and disasters (Public Safety Canada). Public Safety Canada facilitates national coordination across federal agencies

to implement a comprehensive approach to emergency management on federal lands and properties. One significant wildfire program in Canada is the FireSmart program, which aims to reduce the risk wildfires pose to communities and structures. This program focuses on educating homeowners and communities on actions they can take to mitigate wildfire risks, such as creating defensible space, using fire-resistant building materials, and managing vegetation around the homes (Westhaver et al., 2007; Ergibi and Hesseln, 2020). Another wildfire management tool employed in Canada is prescribed burns. Additionally, Canada has implemented "let burn policies," wherein authorities choose not to suppress wildfires that do not pose a threat to assets (McFarlane et al., 2006).

In recent years, there has been a push to enhance the use of technology in wildfire management (McFayden et al., 2023). This includes utilizing satellite imagery to detect fires, drones to monitor fire activity, and computer models to predict fire behavior. These technologies can assist fire management agencies make science-informed decisions and respond quickly to wildfires. However, Canada's current suppression policies are making the wildland-urban interface (WUI) more vulnerable, especially considering the expected worsening of wildfires due to climate change (Parisien et al., 2020).

3.1.4. Australia

Australia's fire regimes exhibit diversity due to the vastness of its land area and the heterogeneity of its ecosystems (Murphy et al., 2013). Historically, Australia transitioned from a mosaic burning practice conducted by aboriginal people to a wildfire management approach primarily focused on firefighting to minimize fire impacts (Pyne, 1991). However, more recently, severe fires have prompted a new transition towards integration of wildfire prevention and wildfire risk management, with the aim of increasing Australia's resilience to fire (Council to Australian Governments, 2011).

The current strategy is primarily centered around protecting life and property while simultaneously maintaining the ecosystem services provided by the Australian ecosystems (Forest Fire Management Group, 2014). However, extensive land fragmentation in Australian settlements has resulted in numerous wildland-urban interface areas, which in turn exposes many lives and properties to wildfire risk (Gonzalez-Mathiesen et al., 2021). To achieve the proposed objective, current wildfire policies strive to integrate wildfire management and spatial planning policies incorporating performance-based designs, fire risk education, and self-protection measures, with a particular focus on wildland-urban interface areas (Baker et al., 2020). The National Bushfire Management Policy Statement (Forest Fire Management Group, 2014) signed by all states and territories, serves as a document of intentions to implement effective fire management practices. However, its implementation has been slow and partial, leading to recent updates and the inclusion of key performance indicators to support its execution (Forestry Australia and Forest Fire Management Group, 2022). The complexity of policy implementation can be observed in the case of prescribed burns (Russell-Smith et al., 2020). Furthermore, the National Construction Code (NCC), a crucial regulatory instrument, undergoes constant review and varies in adaptation to different states and territories (Baker et al., 2020). Lastly, the "Stay and Defend or Leave Early" strategy exemplifies shared and individual responsibility in risk management policies (McCaffrey and Rhodes, 2009). However, after the devastating fires of 2009, the strategy was changed to "Prepare, act, survive" (Xanthopoulos et al., 2011).

3.1.5. United Kingdom

The United Kingdom has a relatively low risk of wildfires, but it has experienced some significant wildfires in recent years, with 2018 and 2022 being among the worst years in terms of the number of wildfires recorded. Climate change is recognized as a significant threat, leading to an increasing risk of wildfires in the UK (Perry et al., 2022; Smith et al., 2020). To address climate change and its impacts, the government has established the Climate Change Act as a guide for the country's response. While each nation within the UK has different wildfire and land management strategies in place, they often align. The government has also implemented the Countryside Stewardship Scheme to support farmers and landowners in managing their land to reduce the risk of wildfires. The Met-Office plays a crucial role by issuing Daily Hazard Assessments, which inform authorities about the level of wildfire risk in different areas. This information is utilized to invoke public land closure through the CROW Right of Way Act.

On the prevention side, prescribed burning is not commonly used in the UK as a tool to reduce fuel loads and prevent wildfires in the UK. However, small-scale burning is employed in some areas as a management tool for heathland and peatland habitats. The Home Office serves as the Lead Government Department for wildfires, while local fire and rescue services are primarily responsible at the local level, receiving support from the national government when necessary. Currently, there are no mandatory building codes in the UK for the constructing homes and buildings in wildfire-prone areas. However, the Forestry Commission provides guidance to enhance wildfire resilience in forests, and this guidance has been applied in some housing developments in the South of England.

3.1.6. Portugal

Public policies and legislation related to fire in Portugal have changed over time, going through various cycles over several centuries (Pinho and Mateus, 2019). Following the fire season of 2003 and 2005, a comprehensive reform of policy and legislation related to forest fire defense was implemented (Mateus and Fernandes, 2014; Pinho and Mateus, 2019). This reform focused on five strategic axes: increasing territorial wildfire resilience, reducing wildfire incidence, enhancing firefighting and wildfire management effectiveness, restoring ecosystems, and adapting to a functional organic structure (Resolução do Conselho de Ministros no. 65/2006). The reform emphasized three priority domains: structural prevention, surveillance, and firefighting. While many actions were successfully carried out, the implementation of several recommended measures was deficient due to multiple factors (Beighley and Hyde, 2018). However, the catastrophic fire season of 2017 prompted a transition from a strong fire suppression policy to one that emphasizes the importance of prevention. The National Plan for Integrated Fire Management (PNIGFR) (Conselho de Ministros, 2020), although non-regulatory, became the most significant policy instrument, aiming to reform the previous model which was criticized for its excessive complexity (Observatório Técnico Independente et al., 2018). The National Action Programme (PNA) was implemented to put the defined PNGIFR system into practice. It redefined existing policies, adapting or reinforcing them, and establishing new ones to incorporate the new vision and respond effectively. A central organization, the Agency for Integrated Rural Fire Management, was created to manage the implementation of wildfire policies and seek continuous improvement. The National Plan for Integrated Fire Management identified three main areas which are: building a sustainable rural landscape, protecting rural spaces, and safeguarding people and property (Conselho de Ministros, 2018). In the initial stage of this transition, the focus is on the protection of people and property, gradually implementing additional prevention measures through regulatory, informational, and cooperative policy instruments. In the medium to long term, the objective is to develop a sustainable rural landscape, primarily through economic and territorial policy instruments outlined in the Landscape Transformation Program (Conselho de Ministros, 2020).

3.1.7. Italy

Italy has implemented several laws and policies aimed at preventing and managing wildfires, protecting forests and natural resources, and ensuring public safety. Forest management in Italy is governed by the "Forest Law," which was last updated in 2018 (D. L.vo 03/04/2018). This law regulates the management, protection, and use of forests and

other wooded areas, with the goal of preserving their ecological, economic, and social functions. Additionally, Italy has the National Framework Law 353/2000, which governs wildfire risk management and was last updated in 2021. This law aims to enhance collaboration among various agencies and stakeholders, guiding fire prevention, preparedness, and response efforts.

Under Italian law, administrative regions are responsible for developing Regional Fire Management Plans, which outline the fire management strategy implemented in each region. Municipalities are also required to develop Fire Prevention Plans (Piano di Protezione Civile Comunale). These plans identify areas at risk of wildfires, establish prevention and control measures, allocate resources for implementing the fire management strategy, and define the roles and responsibilities of different stakeholders. In the past, the Italian State Forestry Corps (Corpo Forestale dello Stato or CFS) played a significant role in fire prevention, acting as a park ranger force and protecting forests and the environment. This agency, with police powers, was responsible for forest fire prevention and investigation of fire causes. It also engaged in fire suppression through 15 regional commands and a fleet of 22 firefighting aircraft. However, in the beginning of 2017, the CFS was disbanded by a government decision, and its duties and some personnel were incorporated into the Carabinieri, a military police corp. A new unit known as the Command of the Forest, Environmental and Agri-food units (Commando unità forestali, ambientali e agrolimentari), was formed. At that time, the National Fire Services (Vigili del Fuoco) – under the Ministry of Interior and usually operated in urban areas – were responsible for most wildfire control duties. Administrative regions receive support from the National Civil Protection in firefighting activities, which also coordinates the national air fleet. At the regional level, wildfire risk management policies are implemented by

Civil Protection or regional forestry agencies, while the regional Environmental Protection Agency IES (ARPA) provides wildfire danger forecasting, and monitors air quality, water quality, and other potential impacts of wildfires. Furthermore, Italy also participates in the EU's Civil Protection Mechanism, which aims to improve coordination and cooperation among EU member states in preventing and managing wildfires.

3.1.8. France

Unlike most other Southern European countries, where wildfires impact the entire territory, wildfires in Southern France predominantly affect specific regions. This is due to the implementation of a rigorous fire prevention and suppression program that was launched in 1987 (Fox et al., 2015; Ruffault and Mouillot, 2015). In 1994, a new fire policy and strategy called "Vulcain" was established in response to devastating fires that occurred from 1979 to the 1990s. The Vulcain strategy prioritized prevention over suppression and placed significant emphasis on suppressing all ignitions (Battesti, 1997; Curt and Frejaville, 2018). While adjustments have been made over time to account for the 2003 and 2016 fires, as well as the potential impacts of climate change (Curt and Frejaville, 2018), Vulcain remains a crucial milestone in France's modern policy history.

The national and local forest fire prevention policies are implemented in only 32 out of the 101 administrative districts, particularly in the fire-prone regions of Corsica and Provence-Alpes-Cote d'Azur in the south-eastern France. The national government establishes a unified land use planning process framework for the entire country, and then the administrative districts require the implementation of risk prevention plans (PPR), which include measures to reduce wildfire risks, by local jurisdictions (Kocher and Butsic, 2017). Local jurisdictions develop their own land use plans, which must incorporate the PPR requirements.

As the wildlands of Southern France have expanded, there has been a corresponding increase in housing construction within these densely vegetated areas known as the wildland-urban interface (WUI). Since 1975, housing construction in these areas has increased by 20% (Kocher and Butsic, 2017). This recent and ongoing sprawl of the wildland-urban interface is one of the land-use changes impacting the Mediterranean Fire regime (Fernandes et al., 2011). The WUI tends to concentrate fire hot spots (Ganteaume and Long-Fournel, 2015), and it plays a significant role in most fire regimes accounting for 49.3% of fires in the Bouches de Rhone district (Chappaz and Ganteaume, 2022). To prevent and control wildfires in the fire-prone areas particularly in the southeast, France has strengthened The Forest Code, which is the primary law governing the management and protection of French forests. This has been accomplished through prefectural orders aimed at increasing fire prevention measures, particularly at WUI. Fire suppression efforts are carried out by the French firefighters who belong to the "Direction des Sapeur-pompiers" of the Sécurité Civile, a civil defense agency of the French Government. Their goal is to suppress new fire ignitions within 10 min of reporting (Alexandrian, 1999; Kocher and Bustic, 2017). Currently, approximately one third of the fire budget is allocated to prevention, while two thirds are dedicated to suppression, highlighting the need for a rebalancing towards fire prevention. Although numerous studies have demonstrated the effectiveness of the fire policy implemented after devastating wildfires, concerns arise regarding its long-term sustainability and its ability to mitigate fire risks in the context of climate change (Alexandrian, 2008; Fox et al., 2015; Curt et al., 2016; Curt and Frejaville, 2018; Evin et al., 2018). These concerns are further amplified when multiple extreme fire events occur simultaneously (Ganteaume et al., 2021). Therefore, scholars advocate for a comprehensive policy that enables coexistence with fires (Niamir-Fuller et al., 2012; Moritz et al., 2014; Curt and Frejaville, 2018; Eloy et al., 2019; Essen et al., 2021). This approach should involve the participation of public and private entities, increased public awareness to enhance acceptance and enforcement of regulations, and the promotion of fire-smart landscapes and fire-resilient ecosystems.

3.1.9. Greece

Wildfires pose a significant environmental concern in Greece, prompting the implementation of various laws and policies aimed at preventing and managing them.

The Forest Law 998/1979 established a legal framework for the protection, management, and conservation of Greek forests. It regulates issues related to forest ownership, exploitation, use, and protection. It defines the responsibilities of forest owners, the government, and citizens in the protection of forests against wildfires. Similarly, the Forest Fire Prevention and Suppression Law 2690/1999 focuses on the prevention and suppression of forest fires in Greece. It established the Hellenic Fire Corps as the coordinating authority responsible for firefighting efforts across different agencies, and for enforcing fire prevention regulations. This law also introduced penalties for individuals who negligently or intentionally ignite fires (arson). Law 4069/2021 amended the previous legislation to enhance the Hellenic Fire Corps' capacity to prevent and respond to wildfires. It also established a new legal framework for the establishment of a national system for forest and other land use planning and management.

In 2012, the National Action Plan for Forest Fire Prevention and Management was established, providing a comprehensive framework for preventing, detecting, and suppressing wildfires in Greece. It

includes measures for post-fire recovery and the restoration of affected areas. The plan outlines the roles and responsibilities of various agencies, institutions, and stakeholders in its implementation. Additionally in 2014, the National Forest Fire Danger Rating System was developed to assess wildfire risk in different parts of Greece.

Corresponding to Italy, Portugal, and France, Greece is also a member of the European Union, which means it follows the EU Forest Strategy for sustainable forest management. This strategy encompasses measures for wildfire preventing and management, as well as the promotion of forest biodiversity and ecosystem services.

3.1.10. Cyprus

Cyprus is a Mediterranean island with a complex socio-political situation that interferes with wildfire prevention strategies. This situation is characterized by longstanding political tensions between the North and South, where the Republic of Cyprus is the internationally recognized entity, and Turkey occupies almost 40% of the island since 1974. The divided nature of the country hinders the implementation of effective wildfire prevention strategies as responsibility for managing the environment and natural resources falls under different authorities, often with limited coordination and collaboration. The United Nations has established a buffer zone that runs across the island, separating the two communities, which also presents difficulties in implementing wildfire management measures that span across the island. Furthermore, the large number of actors in the country can result in delayed decision-making processes and hinder the effective coordination of resources, which can be crucial in the event of a wildfire outbreak. Republic of Cyprus has three organizations actively engaged in firefighting: the Fire Service, the Department of Forests, and the Civil Defense Force (Boustras et al., 2008). However, a lack of coordination among all the organizations is perceived as a significant constraint (Herrero et al., 2010). In addition, the Forest Law and the Fire Fighting Action Plan in Rural Areas both provide the national institutional framework for managing wildfires and outline the responsibilities of all parties involved in fighting fires (Department of Forest, Cyprus). According to the Forest Law, the Department of Forests, under the Ministry of Agriculture, Rural Development, and Environment handles the legal, administrative, and technical aspects of wildfire suppression. In Cyprus, fires that originate or spread within state forest territory or less than 2 km from state forest boundaries, or those that the director of the department of forests deems as posing a threat to state forest land, are categorized as wildfires (Fernandez-Anez et al., 2021).

As a member of the European Union, Cyprus is also subject to EU policies and directives concerning wildfire prevention. The EU's Forest Fire Prevention and Information System (EFFIS) provides real-time monitoring of wildfires and other forest-related risks across Europe. It also supports the development of effective wildfire prevention and management strategies.

3.2. Strengths and weaknesses of wildfire policies and legislations

By thoroughly examining policy documents, legal frameworks, and engaging in discussions with key-informants from each country, we ensured a systematic and comprehensive analysis of relevant information. This approach enabled us to effectively gather and evaluate crucial data. The strategic implementation of both questionnaires and document reviews unveiled the perceived strengths and weaknesses (Table 1) embedded in the wildfire policies of each country. Simultaneously, the workshop served as a platform for broadening the theoretical framework and pinpointing areas for policy improvement.

Moreover, our research has yielded insights into shared characteristics among nations, allowing us to pinpoint vulnerabilities in fire management practices. These vulnerabilities encompass the imperative to integrate considerations for climate change, as well as adaptations in land use and land cover. Such alterations can result in an expansion of forested areas while decreasing agricultural land, consequently leading to an increased accumulation of fuel biomass conducive to potential fires. Additionally, the expansion of Wildland-Urban Interface areas contributes to an increased risk of fire ignitions and the presence of vulnerable regions.

To offer tailored suggestions for enhancing wildfire policies, each country has been analyzed individually, though they do share some commonalities.

Table 1
Perceived Strengths and Weaknesses in wildfire policies and legislations.

COUNTRIES	STRENGTHS	WEAKNESSES
South Africa	- provides for the establishment of Fire Protection Associations, which bring together landowners and other stakeholders to collectively manage risk across landscapes.	- The legislation may not be well-resourced or fully enforced, especially in rural areas. - The likelihood and severity of wildfires are increasing due to the predicted increase of fire weather associated with climate change.
USA	- legal and non-legal frameworks for agencies to coordinate efforts and implement preventive measures such as fire adapted communities and more effective response. - cooperation between federal, state, and local agencies. - use of science-based approaches to manage wildfires	- insufficient resources resulting from underfunding have hampered prevention and mitigation efforts for wildfires. However, the recent passage of the bipartisan infrastructure law and inflation reduction act has brought about a substantial influx of resources to address this issue and assist in tackling the wildfire problem - Conflicting interests among stakeholders, such as property owners and environmental conservationists, lead to political challenges in implementing legislation.
Canada	- provides guidelines and regulations for activities that could potentially cause wildfires, such as campfires and fireworks.	- Legislation is not fully enforced, leading to non-compliance and an increased risk of wildfires. - Climate change is making wildfires more frequent and intense, and current legislation may not be able to keep up with these changes.
Australia	- The legislation is well-established and enforced. - Well-resourced fire infrastructure	- The legislation may not fully address the increasing risk of wildfires due to climate change. - Requires more public awareness and engagement to promote community-based resilience to wildfires.
United Kingdom	- establishes guidelines for land management practices that reduce the risk of wildfires. - provides funding for research into fire prevention and suppression technologies.	- Wildfire does not receive as much attention or funding as other natural disasters, such as flooding. - Lack of resources and support for wildfire management efforts. - Challenges in implementing policies across different regions with varying land management practices and cultural attitudes towards fire. - No national strategy for wildfire management in England, however strategic approaches are forming in Scotland, Wales, and Northern Ireland. - As the UK has a relatively cooler and wetter climate,

(*continued on next page*)

Table 1 (*continued*)

COUNTRIES	STRENGTHS	WEAKNESSES
		wildfires are less frequent than in other regions, which can lead to a lower prioritization of wildfire prevention efforts.
Portugal	- Mandates clearing of vegetation around buildings. - Supports forest owners to undertake preventive measures like thinning and pruning.	- Enforcement of the legislation is weak, which allows some property owners to ignore their obligations. - Legislation focuses primarily on preventing fires. - Legislation does not address climate change and land use practices, which limits its effectiveness.
Italy	- The main responsibility lies within the purview of the 20 regions as opposed to the state level. This approach enables the consideration of the cultural and ecological heterogeneity across the nation. - Regional fire management plans involve intersectoral collaboration and risk mitigation policies. - Large investments in fire danger forecasting and firefighting. - Impose penalties on those causing fire through negligence or intentional acts.	- No National Forestry authority (Forest Service) to coordinate forestry policies - Reduced coordination between ministries with responsibilities for fire risk management - Poor investment wildfire prevention policies and in fire risk awareness among citizens - Poor regulation of fire use in agro-pastoral and forestry sectors - Legislation can be difficult to enforce, particularly in remote or difficult-to-access areas. - Legislation can be overly bureaucratic, hindering effective implementation.
France	- Laws to Involve the community: to maintain their property, creation of fire breaks, and fuel management zones. - Effective fire suppression measures (early massive attack of the fire, etc.) when not in extreme weather conditions.	- Inadequate funding and resources - Lack of enforcement - Lack of awareness and education - Climate change has created more favorable conditions for extreme wildfires, which may make existing measures less effective - Successful fire suppression is likely to lead to the so-called "fire paradox" effect, i.e., fuel build-up that will cause extreme intensity devastating fires in the future.
Greece	- Provides a legal framework for addressing the issue of wildfires and establishes responsibilities for relevant authorities. - Mandates the creation of fire prevention plans and establishes penalties for those violating regulations.	- A fire suppression agency has the main role in forest fire management, while the Forest Service is weakened, leading to inadequate forest management and fuel build-up. - Cooperation between agencies is less than optimal, so in difficult conditions help is requested from abroad. - Law enforcement is often weak, with inadequate monitoring and enforcement mechanisms. - Political and economic factors limit the effectiveness of regulations. - Challenges in the effectiveness of regulations due to extreme fire weather conditions - Absence of collaboration with the scientific community.
Cyprus	- Established measures for the management of forests and other natural areas, including fire prevention plans and the establishment of firebreaks	- Ineffective law enforcement - Lack of resources and personnel - Lack of interagency exchange and collaboration

3.3. Recommendations for improving wildfire policy and legislation

It is essential to improve wildfire policies to mitigate the damage caused by wildfires in the context of climate change (more frequent extreme events expected). Emphasis should be put on creating awareness among people (Balch et al., 2017; Tedim et al., 2016), building wildfire-adapted communities (Tedim et al., 2020; Essen et al., 2021),

Table 2
Recommendations to improve wildfire policy in each country.

COUNTRIES	RECOMMENDATIONS
South Africa	Improve integration between the laws, for instance, the Fire Brigades Services Act (1987) is being reviewed and updated ("joining" legislation), which will favor Integrated Fire Management.There is no standardized set of indicators to monitor the results of the policy throughout the country.Regarding the preparation of settlements, building regulations still focus on the inside of buildings not outside, however, this is changing, largely driven by FPAs. - Defensible space has not been widely promoted or included in regulations.
USA	- Long-term strategies are needed. - Collaborative management of landscapes is necessary. - Rural economies need to be supported by fire management strategies. - Creating resilient communities should be prioritized (i.e., implementing local house hardening measures, taking social equity issues into account)
Canada	- Wildfire policies could be more proactive in offering outreach programs and targeting the most vulnerable communities. - Indigenous communities could offer significant assistance in managing wildfires and thus should be involved and empowered. - Cultural burning is an ancient practice that should be included in decision-making, policy action, and implementation. - Landscape management practices for WUI fire disaster mitigation are much cheaper and environmentally friendly than suppression and rebuilding. - More focus and investments in proactive measures, such as forest thinning and prescribed burns in strategic areas could be useful to address the challenges of climate change.
Australia	- Improvement of fire detection and mapping technology (e.g., high-elevation cameras; georeferenced cube satellites) - Improved information to the public regarding risk awareness, preparedness, and evacuation strategies in an emergency event (e.g., early warnings) - State-by-state harmonization of building requirements - Removing barriers to working across state borders[3] - Shift away from response to prevention and mitigation e.g., increased prescribed burns according to risk (controversy related to needed scalability of implemented methods to be effective and resulting adverse smoke impacts on population)
United Kingdom	- Recommended to have a national strategy for wildfire, considering climate change adaptation to provide integrated fire management across and within sectors. - Benchmarking UK policy against best practices in other countries with a climate similar to the UK's future scenario can inform us if current policy anticipates future needs. A benchmarking tool could be developed in this capacity and used by other countries in a similar position to the UK. - Policies with implications for wildfire should explicitly consider long-term wildfire management implications, particularly for policies that may cause fuel-related changes. There is also a need to evaluate these long-term policies to see if they are delivering their objectives on the ground and what impacts they have had. - Need for specific wildfire legislation, which will require engagement with all relevant sectors. - Aligning development planning control mechanisms to recent wildfire patterns.

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[3] (Problem from 2019/2020 fire cross the borders of FRS zones, meaning people on the same fire couldn't effectively communicate with each other)

Table 2 (*continued*)

COUNTRIES	RECOMMENDATIONS
	- Periodic evaluations of previous policies and how they have been implemented. - Improved integrated working between forestry, land management, and fire sectors.
Portugal	It is difficult to provide recommendations for improving Portugal's forest policy due to the extensive knowledge needed and ongoing reforms. Suggestions for improvement exist, some of which have already been solved, showing the system is in constant adaptation and active change. Anticipating and managing conflicts during the implementation phase is crucial The goal is to reach compromises that work for the territories in which the measures are implemented, being time – and context – sensitive.
Italy	Mostly focus on the forest side of wildfires (e.g., as the SNF shows), but a general lack of socioeconomic policies specifically in the framework of wildfires (education; spatial /urban planning; rural development…). Need for monitoring of wildfire actions and policies through key indicators at the national level. Need for more exhaustive indicators, on ecological, social, and economic dimensions around wildfires. Overall: need for truly integrated wildfire policy to counter current *fragmentation between sectors* (forestry, sociocultural dimensions, etc.) and *levels* (national, regional, local).
France	Reduce the high costs generated by compulsory fuel reduction activities in WUI areas and increase resident and stakeholder awareness on fire risk and therefore on the importance of enforcing the regulation on fuel reduction More funds allocated to fire prevention (currently it is 1/3 for fire prevention and 2/3 for fire suppression Increase the resilience of the WUI to fire (resilient landscaping, practices, etc.)
Greece	Need to strengthen forest management through a better supported and organized Forest Service An emphasis should be put in creating resilient landscapes through training, organizing, and supporting farmers and foresters Need to improve citizens' awareness about wildfire consequences and their prevention. Workshops and sensitization about wildfires should be provided to residents and tourists, including in schools. Enhanced collaborations with the research community. Transparency in the procedures for fire danger rating and fire analysis.
Cyprus	- Bridge the gap between laws and their implementation. - Define measurable indicators for forest fire risk reduction. - More transparency in procedures of the forest department (public expenditures) - Speed up change (e.g., legislative updates) and implementation of recommendations (e.g., reports of expert commissions after the Solea fire in 2016 and the Arakapas fire in 2021) - Need for paradigm change (like in the rest of the Mediterranean) – not all fires are bad, and not all fires can be excluded, need for nuanced understanding, better training, and better awareness. - Better communication with the public (Social Media plan, through the news; more focus on prevention in addition to detection and response). - Address the divided Cyprus issue through community and trust-building measures, need for collaboration. - Focus on high-risk areas, e.g., WUI. - Better integration with different fields: agriculture, rural development, sustainable tourism, nature conservation

forest management (Moreira and Pe'er, 2018; Hesseburg et al. 2021), creating firebreaks (Lin et al., 2021; Bowman et al., 2018), investing in firefighting equipment and personnel (Oliveira et al., 2021; Marks--Block and Tripp, 2021), and finding better ways to include science into practice (Dunn et al., 2020; Hessburg et al., 2021).

The incorporation of questions asked during the training and document analysis facilitated the comprehensive collection and analysis of pertinent information. As a result, the subsequent Table 2 offers country-specific recommendations based on the participants viewpoints to mitigate wildfire risks and promote sustainable forest management.

4. Discussion

Wildfires present a pressing global concern, imposing significant environmental, societal, and economic damages (Tedim et al., 2018; Bardgett et al., 2021; Nolan et al., 2021). In response, governments worldwide have adopted diverse policies and legislations to contend with the escalating threat of wildfires. For example, the United States aims to safeguard natural resources and human settlements from wildfire damages, yet this policy has not resulted in substantial changes in affected structures, burned areas, or ecosystems (Busenberg, 2004; Steelman and Burke, 2007; Steelman, 2016; Fischer et al., 2016; Abatzoglou and Williams, 2016; Labaree, 2021). In Europe, wildfire management centers on safeguarding forest ecosystem services (Montiel-Molina, 2013), while in the Mediterranean regions integrate emergency response and restoration measures into civil protection plans (Tedim et al., 2015). The European Union's wildfire policy additionally aims to enhance community resilience. South Africa prioritizes maintaining ecosystem functionality to achieve effective fire management, encompassing the risk of financial liability for damages. In Australia, safeguarding life and property takes precedence, with fuel management emerging as an important tool.

Nevertheless, fire management should not be viewed as a primary reaction to wildfires. Under extreme environmental conditions or simultaneous multiple fire outbreaks, firefighting resources can become overwhelmed (e.g., the 2016 Rognac fire in South-East France). Consequently, it becomes imperative to address root causes and seek long-term, sustainable solutions to growing wildfire management issue (FAO, 2019).

The evolution of fire management encompasses distinct phases within disaster management. During the **preparedness phase**, nations have instituted legal and non-legal frameworks for coordinating and executing preventive measures. Notably, the United States boasts a robust legal framework facilitating efficacious collaboration and the implementation of preventive measure across agencies. In South Africa, Fire Protection Associations unite landowners and stakeholders for collective fire risk management, while Canada provides directives and regulations to manage activities that may trigger wildfires. Italy adopts a regional approach, integrating fire protection plans that account for cultural and ecological diversity. France has instated regulations for fire prevention at both regional and local levels, leading to a gradual reduction in fire occurrences and burned areas over time. These efforts reflect a shared recognition of the significance of proactive interventions.

Nonetheless, these policies and legislations have certain weaknesses. Limited resources and inadequate funding hinder the execution prevention and mitigation measures, making it challenging to address the growing wildfire risk. Equally concerning is the insufficient enforcement of legislation, a common weakens observed across multiple countries. When regulations and guidelines lack stringent enforcement, compliance falters, invariably heightening the wildfire risk. Thus, a strategic shift in governmental investments towards fire management, emphasizing strategic planning and prevention, becomes imperative.

Transitioning to the **response phase** of the disaster management cycle reveal both parallels and discrepancies among countries. Australia has a well-established and well-equipped firefighting infrastructure, reflecting robust response capabilities. France prioritizes early and assertive firefighting strategies under non-extreme conditions. In contrast, Greece has grappled with severe disasters during challenging fire seasons (2007, 2023), largely attributed to inadequate interagency cooperation, necessitating substantial international assistance.

Regarding **recovery and mitigation**, many nations emphasize community-based resilience strategies. The United Kingdom and France focus on heightening public awareness and education for preparedness and recovery. Australia recognizes the significance of community

engagement in fostering resilience. Nevertheless, Greece and Cyprus lag behind in adequate awareness and education initiatives, hindering effective community involvement.

While policies and legislations naturally vary across countries, recurring themes surface, encompassing inadequate funding, lax enforcement, limited interagency coordination, and the reverberating impacts of climate change. Nonetheless, countries also exhibit strengths in their legal frameworks, preventative measures, and response capabilities, underscoring their collective commitment to wildfire management. Collaborative efforts, such as South Africa's Fire Protection Associations and Italy's regional considerations underscore the shared resolve to confront wildfire risks.

To enhance global wildfire management policies, rectifying the identified weaknesses is crucial. This includes instituting effective enforcement mechanisms, intensifying public education and awareness campaigns, and achieving a balanced allocation of policy resources spanning prevention, suppression, and mitigation. As advocated by Moreira et al. (2020) policy effectiveness ought to be gauged based on the prevention of socio-ecological damage and loss, transcending mere consideration of burned acreage.

5. Conclusions

Governments worldwide have implemented policies and legislation to address the escalating risks of wildfires, prompting an examination of their effectiveness. This assessment spans multiple countries, spotlighting perceived strengths, weaknesses, and outcomes. The study includes a comprehensive fire management framework that traverses disaster management phases, from preparedness to recovery. Amidst common challenges such as insufficient funding, enforcement gaps, and climate change implications, a collective push for policy refinement emerges through collaborative initiatives like Forest Protection Associations and regional strategies.

Addressing these weaknesses is pivotal for advancing global wildfire management, entailing robust enforcement, heightened public education, and equitable resource allocation for prevention, suppression, and mitigation. Heightened wildfire frequency and severity necessitate effective risk policies, prompting a scrutiny of ten nations' strategies, their merits, and shortcomings, leading to actionable recommendations for enhancement.

Urgency for international collaboration is underlined, with a call for shared resources during crises and knowledge exchange to bolster policies and systems. Essential is the adoption of a comprehensive fire management framework, seamlessly integrating systematic assessment, planning, and management across disaster management stages. The holistic global wildfire mandate necessitates climate change integration and augmented coordination among stakeholders, promising enhanced efficacy.

While no universal solution exists, the outlined recommendations offer a cornerstone for cooperative efforts among policymakers, stakeholders, researchers, and communities to mitigate extreme wildfire risks and promote sustainable forest management practices.

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CRediT authorship contribution statement

Pooja Pandey: Conceptualization, Methodology, Investigation, Resources, Data curation, Writing – original draft, Visualization. **Gabriela Huidobro:** Data curation, Writing – original draft, Writing – review & editing. **Luis Filipe Lopes:** Data curation, Writing – original draft, Writing – review & editing. **Anne Ganteaume:** Writing – review & editing. **Davide Ascoli:** Writing – review & editing. **Conceição Colaco:** Writing – review & editing. **Gavriil Xanthopoulos:** Writing – review & editing. **Theodore M. Giannaros:** Writing – review & editing. **Rob Gazzard:** Writing – review & editing. **Georgios Boustras:** Writing – review & editing. **Toddi Steelman:** Writing – review & editing. **Valerie Charlton:** Writing – review & editing. **Euan Ferguson:** Writing – review & editing. **Judith Kirschner:** Writing – review & editing. **Kerryn Little:** Writing – review & editing. **Cathelijne Stoof:** Writing – review & editing. **William Nikolakis:** Writing – review & editing. **Carmen Rodriguez Fernández-Blanco:** Investigation. **Claudio Ribotta:** Investigation. **Hugo Lambrechts:** Investigation. **Mariña Fernandez:** Investigation. **Simona Dossi:** Investigation.

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Data availability

No data was used for the research described in the article.

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Appendix A

The course participants were asked the following questions, prepared by the corresponding author. To answer these questions, each participant had to analyze the policy documents (legally binding documents and non-binding programs) and seek guidance from the country tutor.

What are the current policies (laws, acts, regulations, standards) in wildfire prevention and suppression for the different levels (local to national) in your case study?
What is the legislative status (e.g., is it legally binding)?
Which entities are involved in decision making, implementation and review of wildfire policies?
What are the main objectives and actions taken? Are there any key monitoring indicators?
What are the issues prioritized in the policy to reach the objectives?
How are the policies linked to different areas (e.g., urban/rural development, building regulations, civil protection, climate change adaptation, etc.)?
What is the allocated budget (if public)?
Discuss: what are your recommendations to improve wildfire policies in your case study?
Are there any concrete examples of best practice from your case study that could be implemented in different regions?

References

Abatzoglou, J.T., Williams, A.P., 2016. Impact of anthropogenic climate change on wildfire across western US forests. Proc. Natl Acad. Sci. 113 (42), 11770–11775.

Act 101, 1998. National Veld and Forest Fire Act. Government Gazette, 27 November 1998. Consulted in December 2022. https://www.gov.za/sites/default/files/gcis_document/201409/a101-98.pdf.

Althaus, C., Ball, S., Bridgman, P., Davis, G., Threlfall, D., 2022. The Australian Policy Handbook: A Practical Guide to the Policymaking Process. Taylor & Francis.

Alexandrian, D. and Esnault, F., 1999. Public policies affecting forest fires in the Mediterranean basin. *FAO Forestry Paper*, pp.39–58.

Alexandrian, D., 2008. Les statistiques" feux de forêt" de ces trente dernières années. For. Méditerr. 29 (4), 377–384.

Baker, G., Webb, A., Whiting, P., 2020. Regulatory controls for buildings in wildfire-prone areas of Australia. Fire Technol. 56 (5), 1903–1935.

Balch, J.K., Bradley, B.A., Abatzoglou, J.T., Nagy, R.C., Fusco, E.J., Mahood, A.L., 2017. Human-started wildfires expand the fire niche across the United States. Proc. Natl Acad. Sci. 114 (11), 2946–2951.

Bardgett, R.D., Bullock, J.M., Lavorel, S., Manning, P., Schaffner, U., Ostle, N., Chomel, M., Durigan, G., Fry, E.L., Johnson, D., Lavallee, J.M., 2021. Combatting global grassland degradation. Nat. Rev. Earth Environ. 2 (10), 720–735.

Battesti, A., 1997. Vulcain ou l'histoire d'une tentative pour commencer à changer les choses dans le système" Feux de Forêts", par la transparence et la convivialité. For. Méditerr. 18 (2), 143–145.

Beighley, M., Hyde, A.C., 2018. Portugal Wildfire Management in a New Era Assessing Fire risks, Resources and Reforms. Centro de Estudos Florestais–Instituto Superior de Agronomia/Universidade de Lisboa, Lisboa, Portugal.

Bilbao, B., Steil, L., Urbieta, I.R., Anderson, L., Pinto, C., González, M.E., Millán, A., Falleiro, R.M., Morici, E., Ibarnegaray, V. and Pérez-Salicrup, D.R., 2020. Wildfires. *Adaptation to climate change risks in ibero-American countries;* Moreno, JM, Laguna-Defior, C., Barros, V., Calvo Buendía, E., Marengo, JA, OswaldSpring, U., *Eds*, pp. 435–496.

Bond, W.J., Archibald, S., 2003. Confronting complexity: fire policy choices in South African savanna parks. Int. J. Wildl. Fire 12 (4), 381–389.

Boustras, G., Bratskas, R., Pourgouri, S., Michaelides, A., Efstathiades, A. and Katsaros, E., 2008. A report on forest fires in Cyprus.

Bowman, D.M., Daniels, L.D., Johnston, F.H., Williamson, G.J., Jolly, W.M., Magzamen, S., Rappold, A.G., Brauer, M., Henderson, S.B., 2018. Can air quality management drive sustainable fuels management at the temperate wildland–urban interface? Fire 1 (2), 27.

Bowman, D.M., Kolden, C.A., Abatzoglou, J.T., Johnston, F.H., van der Werf, G.R., Flannigan, M., 2020. Vegetation fires in the Anthropocene. Nat. Rev. Earth Environ. 1 (10), 500–515.

Bridgett, J.A., Van Wilgen, B.W., Kruger, F.J., Forsyth, G.G., Jayiya, T.P., Kruger, L., 2003. A new approach to wildland fire management in South Africa. In: Proceedings of the rd International Wildland Fire Conference and Exhibition. Sydney, Australia.

Busenberg, G., 2004. Wildfire management in the United States: the evolution of a policy failure. Rev. Policy Res. 21 (2), 145–156.

Calkin, D.E., Thompson, M.P., Finney, M.A., 2015. Negative consequences of positive feedbacks in US wildfire management. For. Ecosyst. 2 (1), 1–10.

Chappaz, F., Ganteaume, A., 2022. ("[PDF] Role of land-cover and WUI types on spatio-temporal dynamics of ..."). Risk Anal.

Council of Australian Governments, 2011. National Strategy For Disaster Resilience: Building the Resilience of Our Nation to Disaster. Council of Australian Government.

Council of Ministers, 2018. Decree-LAW NO. 12/2018, of February 16. Repub. Diary, 1st Ser. - No. 34 990–995.

Conselho de Ministros, 2020. Resolução do Conselho de Ministros n.o 45-A/2020 - Plano Nacional de Gestão Integrada de Fogos Rurais. ("Sistema de Gestão Integrada de Fogos Rurais (SGIFR)") Diário da República, 1.a série - N.o 115 - 16 de Junho de 2020, Lisboa.

Curt, T., Fréjaville, T., Lahaye, S., 2016. Modelling the spatial patterns of ignition causes and fire regime features in southern France: implications for fire prevention policy. Int. J. Wildl. Fire 25 (7), 785–796.

Curt, T., Frejaville, T., 2018. Wildfire policy in Mediterranean France: how far is it efficient and sustainable? Risk Anal. 38 (3), 472–488.

Dabiri, J.O., Sullivan, K.D., Carter, A., Fung, I., Pacala, S. and Press, W., 2023. Modernizing Wildland Firefighting to Protect Our Firefighters: report to the President.

Department of Forests, Cyprus (2023) http://www.moa.gov.cy/moa/fd/fd.nsf/fd51_en/fd51_en?OpenDocument.

Dunn, C.J., D O'Connor, C., Abrams, J., Thompson, M.P., Calkin, D.E., Johnston, J.D., Stratton, R., Gilbertson-Day, J., 2020. Wildfire risk science facilitates adaptation of fire-prone social-ecological systems to the new fire reality. Environ. Res. Lett. 15 (2), 025001.

DFFE Department: Forestry; Fisheries and the Environment. Republic of South Africa. Consulted in December 2022: https://www.dffe.gov.za/projectsprogrammes/workingonfire.

Eloy, L., Bilbao, A.B., Mistry, J., Schmidt, I.B., 2019. From fire suppression to fire management: advances and resistances to changes in fire policy in the savannas of Brazil and Venezuela. Geogr. J. 185 (1), 10–22.

Ergibi, M., Hesseln, H., 2020. Awareness and adoption of FireSmart Canada: barriers and incentives. For. Policy Econ. 119, 102271.

Essen, M., McCaffrey, S., Abrams, J., Paveglio, T., 2021. Improving wildfire management outcomes: shifting the paradigm of wildfire from simple to complex risk. J. Environ. Plann. Manag. 1–19.

Evin, G., Curt, T., Eckert, N., 2018. Has fire policy decreased the return period of the largest wildfire events in France? A Bayesian assessment based on extreme value theory. Nat. Hazards Earth Syst. Sci. 18 (10), 2641–2651.

FAO Strategy on Forest Fire Management., 2019. https://www.fao.org/3/cb6816en/cb6816en.pdf.

Farkhondehmaal, F., Ghaffarzadegan, N., 2022. A cyclical wildfire pattern as the outcome of a coupled human natural system. Sci. Rep. 12 (1), 5280.

Federal Land Assistance, Management and Enhancement Act of 2009 (FLAME Act). 111th Congress (2009-2010). Consulted in December 2022 https://www.congress.gov/bill/111th-congress/house-bill/1404.

Federation of American Scientists., (2023). *Wildland fire policy recommendations.* Available at: https://fas.org/publication/wildland-fire-policy-recommendations/.

Fernandes, P.M., Botelho, H.S., 2003. A review of prescribed burning effectiveness in fire hazard reduction. Int. J. Wildl. Fire 12 (2), 117–128.

Fernandes, P.M., 2011. The FIRE PARADOX project: understanding fire ecology and implications for management. For. Ecol. Manage. 261 (12), 2177–2254.

Fernandes, P.M., Guiomar, N., Mateus, P., Oliveira, T., 2017. On the reactive nature of forest fire-related legislation in Portugal: a comment on Mourão and Martinho (2016). Land Use Policy 60, 12–15.

Fernandez-Anez, N., Krasovskiy, A., Müller, M., Vacik, H., Baetens, J., Hukić, E., Kapovic Solomun, M., Atanassova, I., Glushkova, M., Bogunović, I., Fajković, H., 2021. Current wildland fire patterns and challenges in Europe: a synthesis of national perspectives. Air, Soil Water Res. 14, 11786221211028185.

Fischer, A.P., Spies, T.A., Steelman, T.A., Moseley, C., Johnson, B.R., Bailey, J.D., Bowman, D.M., 2016. Wildfire risk as a socioecological pathology. Front. Ecol. Environ. 14 (5), 276–284.

Forest Fire Management Group, 2014. National bushfire management policy statement for forests and rangelands 1–24.

Forestry Australia & Forest Fire Management Group, 2022. Turning the Goals of the National Bushfire Management Policy Statement into Objectives and Key Performance Indicators. Forestry Australia.

Forsyth, G.G.; Kruger, F.J. and Le Maitre, D.C. 2010. National veldfire risk assessment: analysis of exposure of social, economic, and environmental assets to veldfire hazards in South Africa. CSIR Report No: CSIR/NRE/ECO/ER/2010/0023/C. Consulted in December 2022 https://www.firestop.co.za/FPA%20Docs/nationalveldfire_riskassessment_reportmarch2010.pdf.

Fox, D.M., Martin, N., Carrega, P., Andrieu, J., Adnès, C., Emsellem, K., Ganga, O., Moebius, F., Tortorollo, N., Fox, E.A., 2015. Increases in fire risk due to warmer summer temperatures and wildland urban interface changes do not necessarily lead to more fires. Appl. Geogr. 56, 1–12.
Franklin, J.F., Agee, J.K., 2003. Forging a science-based national forest fire policy. Issues Sci. Technol. 20 (1), 59–66.
FynbosFire. (2023) The integrated Fire Management Handbook. Establishing Fire Protection Associations in South Africa 2016. Retrieved from http://landworksnpc.com/wp-content/uploads/2018/05/A-Guide-to-IFM_Complete_Display.pdf.
Ganteaume, A., Long-Fournel, M., 2015. Driving factors of fire density can spatially vary at the local scale in south-eastern France. Int. J. Wildl. Fire 24 (5), 650–664.
Ganteaume, A., Barbero, R., Jappiot, M., Maillé, E., 2021. Understanding future changes to fires in southern Europe and their impacts on the wildland-urban interface. J. Saf. Sci.Resil. 2 (1), 20–29.
Gonzalez-Mathiesen, C., Ruane, S., March, A., 2021. Integrating wildfire risk management and spatial planning–a historical review of two Australian planning systems. Int. J. Disaster Risk Reduct. 53, 101984.
Graham, R.T., McCaffrey, S., Jain, T.B., 2004. Science Basis For Changing Forest Structure to Modify Wildfire Behavior and Severity. United States Department of Agriculture Forest Service, Rocky Mountain Research Station.
Hall, P.A., 1993. Policy paradigms, social learning, and the state: the case of economic policymaking in Britain. Comp. Polit. 25 (3), 275–296.
Herrero, G., Lázaro, A., Montiel, C., 2010. A comparative assessment of the European forest policies and their influence in wildfire management. In: Proceedings of the 3rd International Symposium on Fire Economics, Planning, and Policy: Common Approaches and Problems, 227. DIANE Publishing, p. 273.
Hessburg, P.F., Prichard, S.J., Hagmann, R.K., Povak, N.A., Lake, F.K., 2021. Wildfire and climate change adaptation of western North American forests: a case for intentional management. Ecol. Appl. 31 (8), e02432.
Hobbs, R.J., Arico, S., Aronson, J., Baron, J.S., Bridgewater, P., Cramer, V.A., Epstein, P. R., Ewel, J.J., Klink, C.A., Lugo, A.E., Norton, D., 2006. Novel ecosystems: theoretical and management aspects of the new ecological world order. Global Ecol. Biogeogr. 15 (1), 1–7.
Hoffman, K.M., Christianson, A.C., Gray, R.W., Daniels, L., 2022. Western Canada's new wildfire reality needs a new approach to fire management. Environ. Res. Lett. 17 (6), 061001.
Howlett, M., 2005. What is a policy instrument? Tools, mixes, and implementation styles. *Designing government: From instruments to governance*, pp.31–50.
Hunter, M.E., 2008. Fire in California's Ecosystems-Edited By Neil G. Sugihara, Jan W. Van Wagtendock, Kevin E. Shaffer, Joann Fites-Kaufman, and Andrea E. Thode.
Jolly, W.M., Cochrane, M.A., Freeborn, P.H., Holden, Z.A., Brown, T.J., Williamson, G.J., Bowman, D.M., 2015. Climate-induced variations in global wildfire danger from 1979 to 2013. Nat. Commun. 6 (1), 7537.
Krott, M., 2005. Forest Policy Analysis. Springer Science & Business Media.
Kocher, S.D., Butsic, V., 2017. Governance of land use planning to reduce fire risk to homes Mediterranean France and California. Land 6 (2), 24 (Basel).
Labaree, A. 2021 *The U.S. government is wasting billions on ineffective wildfire policy, Slate Magazine*. Slate. Available at: https://slate.com/technology/2021/11/fire-industrial-complex-wildfire-policy-suppression.html.
LANDWORKS™. Consulted in December 2022: https://landworksnpc.com/firewise/.
Lin, S., Liu, Y., Huang, X., 2021. How to build a firebreak to stop smouldering peat fire: insights from a laboratory-scale study. Int. J. Wildl. Fire 30 (6), 454–461.
Marks-Block, T., Tripp, W., 2021. Facilitating prescribed fire in Northern California through Indigenous governance and interagency partnerships. Fire 4 (3), 37.
Marques, S., Borges, J.G., Garcia-Gonzalo, J., Moreira, F., Carreiras, J.M.B., Oliveira, M. M., Cantarinha, A., Botequim, B., Pereira, J.M.C., 2011. Characterization of wildfires in Portugal. Eur. J. For. Res. 130, 775–784.
Mateus, P. and Fernandes, P.M., 2014. Forest fires in Portugal: dynamics, causes and policies. *Forest Context and Policies in Portugal: Present and Future Challenges*, pp.97–115.
McCaffrey, S.M., Rhodes, A., 2009. Public response to wildfire: is the Australian "Stay and defend or leave early" approach an option for wildfire management in the United States? J. For. 107 (1), 9–15.
McFarlane, B.L., Stumpf-Allen, R.C.G., Watson, D.O., 2006. Public perceptions of natural disturbance in Canada's national parks: the case of the mountain pine beetle (Dendroctonus ponderosae Hopkins). Biol. Conserv. 130 (3), 340–348.
McFayden, C.B., Hope, E.S., Boychuk, D., Johnston, L.M., Richardson, A., Coyle, M., Sloane, M., Cantin, A.S., Johnston, J.M., Lynham, T.J., 2023. Canadian fire management agency readiness for WildFireSat: assessment and strategies for enhanced preparedness. Fire 6 (2), 73.
Montiel-Molina, C., 2013. Comparative assessment of wildland fire legislation and policies in the European Union: towards a fire framework directive. For. Policy Econ. 29, 1–6.
Moreira, F., Pe'er, G., 2018. Agricultural policy can reduce wildfires. Science 359 (6379), 1001. -1001.
Moreira, F., Ascoli, D., Safford, H., Adams, M.A., Moreno, J.M., Pereira, J.M., Catry, F.X., Armesto, J., Bond, W., González, M.E., Curt, T., 2020. ("FirESmart") Wildfire management in Mediterranean-type regions: paradigm change needed. Environ. Res. Lett. 15 (1), 011001.
Moritz, M.A., Batllori, E., Bradstock, R.A., Gill, A.M., Handmer, J., Hessburg, P.F., Leonard, J., McCaffrey, S., Odion, D.C., Schoennagel, T., Syphard, A.D., 2014. Learning to coexist with wildfire. Nature 515 (7525), 58–66.
Murphy, B.P., Bradstock, R.A., Boer, M.M., Carter, J., Cary, G.J., Cochrane, M.A., Fensham, R.J., Russell-Smith, J., Williamson, G.J., Bowman, D.M., 2013. Fire regimes of a Australia: a pyrogeographic model system. J. Biogeogr. 40 (6), 1048–1058.
Niamir-Fuller, M., Kerven, C., Reid, R., Milner-Gulland, E., 2012. Co-existence of wildlife and pastoralism on extensive rangelands. ... Pastor. Res. Policy Pract. 2, 1–14.
Nikolakis, W., Roberts, E., Hotte, N., Ross, R.M., 2020. Goal setting and Indigenous fire management: a holistic perspective. Int. J. Wildl. Fire 29 (11), 974–982.
Nolan, R.H., Bowman, D.M., Clarke, H., Haynes, K., Ooi, M.K., Price, O.F., Williamson, G. J., Whittaker, J., Bedward, M., Boer, M.M., Cavanagh, V.I., 2021. What do the Australian Black Summer fires signify for the global fire crisis? Fire 4 (4), 97.
Observatório Técnico Independente, Castro Rego, F., Fernandes, P., Sande Silva, J., Azevedo, J., Moura, J.M., Oliveira, E., Cortes, R., Viegas, D.X., Caldeira, D., Duarte Santos, F., 2018. ("(PDF) Avaliação do sistema nacional de proteção civil no âmbito dos ...") Relatório Final. Lisboa.
Oliveira, A.S., Soares-Filho, B.S., Oliveira, U., Van der Hoff, R., Carvalho-Ribeiro, S.M., Oliveira, A.R., Scheepers, L.C., Vargas, B.A., Rajão, R.G., 2021. Costs and effectiveness of public and private fire management programs in the Brazilian Amazon and Cerrado. For. Policy Econ.s 127, 102447.
Parisien, M.A., Barber, Q.E., Hirsch, K.G., Stockdale, C.A., Erni, S., Wang, X., Arseneault, D., Parks, S.A., 2020. Fire deficit increases wildfire risk for many communities in the Canadian boreal forest. Nat. Commun. 11 (1), 2121.
Perry, M.C., Vanvyve, E., Betts, R.A., Palin, E.J., 2022. Past and future trends in fire weather for the UK. Nat. Hazards Earth Syst. Sci. 22 (2), 559–575.
Pinho, J., Mateus, P., 2019. Charcoal portrait: fire management in the context of forestry administration and territorial forest planning. Subsidies for a historical and future perspective. Territorium 26 (II), 61–88.
Pivello, V.R., Vieira, I., Christianini, A.V., Ribeiro, D.B., da Silva Menezes, L., Berlinck, C. N., Melo, F.P., Marengo, J.A., Tornquist, C.G., Tomas, W.M., Overbeck, G.E., 2021. Understanding Brazil's catastrophic fires: causes, consequences and policy needed to prevent future tragedies. Perspect. Ecol. Conserv. 19 (3), 233–255.
Pyne, S.J., 1991. Burning Bush: A Fire History of Australia. Macmillan.
Rego, F.C., Morgan, P., Fernandes, P., Hoffman, C., Castro Rego, F., Morgan, P., Fernandes, P., Hoffman, C., 2021. Fire regimes, landscape dynamics, and landscape management. Fire Sci. From Chem. Landsc. Manag. 421–507.
Ruffault, J., Mouillot, F., 2015. How a new fire-suppression policy can abruptly reshape the fire-weather relationship. Ecosphere 6 (10), 1–19.
Russell-Smith, J., McCaw, L., Leavesley, A., 2020. Adaptive prescribed burning in Australia for the early 21st Century–context, status, challenges. Int. J. Wildl. Fire 29 (5), 305–313.
Smith, A.J., Jones, M.W., Abatzoglou, J.T., Canadell, J.G., Betts, R.A., 2020. Climate change increases the risk of wildfires: september 2020. ScienceBrief. https://ueaeprints.uea.ac.uk/id/eprint/77983/1/ScienceBrief_Review_WILDFIRES_Sep2020.pdf.
Spadoni, G.L., Moris, J.V., Vacchiano, G., Elia, M., Garbarino, M., Sibona, E., Tomao, A., Barbati, A., Sallustio, L., Salvati, L., Ferrara, C., 2023. Active governance of agro-pastoral, forest and protected areas mitigates wildfire impacts in Italy. Sci. Total Environ., 164281
Steelman, T.A., Burke, C.A., 2007. Is wildfire policy in the United States sustainable? J. For. 105 (2), 67–72.
Steelman, T., 2016. US wildfire governance as social-ecological problem. Ecol. Soc. 21 (4) (14 pages).
Tedim, F., Leone, V., Xanthopoulos, G., 2015. Wildfire risk management in Europe. the challenge of seeing the "forest" and not just the "trees.". In: Proceedings of the 13th International Wildland Fire Safety Summit & 4th Human Dimensions of Wildland Fire, Managing Fire, Understanding Ourselves: Human Dimensions in Safety and Wildland Fire, pp. 213–238.
Tedim, F., Leone, V., Xanthopoulos, G., 2016. A wildfire risk management concept based on a social-ecological approach in the European Union: fire Smart Territory. Int. J. Disaster Risk Reduct. 18, 138–153.
Tedim, F., Leone, V., Amraoui, M., Bouillon, C., Coughlan, M.R., Delogu, G.M., Fernandes, P.M., Ferreira, C., McCaffrey, S., McGee, T.K., Parente, J., 2018. Defining extreme wildfire events: difficulties, challenges, and impacts. Fire 1 (1), 9.
Tedim, F., McCaffrey, S., Leone, V., Delogu, G.M., Castelnou, M., McGee, T.K., Aranha, J., 2020. What can we do differently about the extreme wildfire problem: an overview. Extreme Wildfire Events Disast. 1, 233–263.
The National Strategy 2014 *forestsandrangelands.gov*. (2023) Available at: http://www.forestsandrangelands.gov/documents/strategy/strategy/CSPhaseIIINationalStrategyApr2014.pdf.
Tymstra, C., Stocks, B.J., Cai, X., Flannigan, M.D., 2020. Wildfire management in Canada: review, challenges and opportunities. Prog. Disast. Sci. 5, 100045.
UNOPS 2016. *Wildfire prevention, preparedness, and response. A report on a Study Tour to South Africa undertaken by Indonesian Government delegation and stakeholders.* Consulted in December (2022), on http://www.forclime.org/documents/Books/Wildfire%20prevention,%20preparedness%20and%20response-study%20tour%20to%20South%20Africa.pdf.
UN-REDD Programme. 2023 https://www.un-redd.org/fire-management.
Wenzelburger, G., König, P.D., Wolf, F., 2019. Policy theories in hard times? Assessing the explanatory power of policy theories in the context of crisis. Public Organ. Rev. 19, 97–118.
Westhaver, A., Revel, R.D., Hawkes, B.C., 2007. FireSmart®-ForestWise: managing wildlife and wildfire risk in the wildland/urban interface—a Canadian case study. In: Proceedings of the USDA Forest Service, pp. 347–365.
WFLC (Wildland Fire Leadership Council), 2014. The National Strategy. The Final Phase in the Development of the National Cohesive Wildland Fire Management Strategy. U. S. Department of Interior.

Wildland fire mitigation and management commission (no date) USDA. (2023) Available at: https://www.usda.gov/topics/disaster-resource-center/wildland-fire/commission.
Wotton, B.M., Flannigan, M.D., Marshall, G.A., 2017. Potential climate change impacts on fire intensity and key wildfire suppression thresholds in Canada. Environ. Res. Lett. 12 (9), 095003.
Xanthopoulos, G., Bushey, C., Arnol, C., Caballero, D., 2011. Characteristics of wildland–urban interface areas in Mediterranean Europe, North America and Australia and differences between them. In: Proceedings of the 1st International Conference in Safety and Crisis Management in the Construction, Tourism and SME Sectors. Nicosia, Cyprus, pp. 24–28.