3 Adapting policies and practices to extreme wildfires: A cross-country review

This chapter provides an overview of the trends in countries' policies and practices in response to the growing occurrence of extreme wildfires. The analysis is informed by the findings of five in-depth country case studies conducted in Australia, Costa Rica, Greece, Portugal and the United States, in addition to a desk review of policies and practices adopted by countries globally. The chapter assesses whether and how countries have adapted their policies and practices in light of the growing occurrence of extreme wildfires. In doing so, it highlights the indispensable and growing role prevention measures play in limiting the impacts and costs of extreme wildfires. The chapter identifies good practices and highlights findings and recommendations for designing a conducive enabling environment.

3.1. Introduction

The frequency and severity of wildfires, as well as the duration of the wildfire season, are on the rise in many regions around the world (see Chapter 2). In Australia, average wildfire frequency almost doubled between 1980 and 2020 and burned forest area increased by 350% between the early 1990s and 2018 (Canadell et al., 2021[1]). In the United States, wildfire severity (i.e. the degree of ecosystem impacts caused by a fire) increased eightfold between 1985 and 2017 across western forests (Parks and Abatzoglou, 2020[2]), while globally the duration of the fire weather season (i.e. the annual periods in which meteorological conditions are conducive to fire) increased by 27% between 1979 and 2019 (Jones et al., 2022[3]). The growing occurrence of wildfire extremes has challenged countries. Extreme wildfires have caused a high number of fatalities, with the extreme 2009 Black Saturday wildfires in Australia claiming over 180 lives (EM-DAT, 2023[4]). They have also caused detrimental impacts on ecosystems. In the 2017 wildfires in Chile, nearly 40% of critically endangered ecosystems suffered medium to high damage (van Hensbergen and Cedergren, 2020[5]). The 2018 Camp Fire in California, United States, caused an unprecedented USD 19 billion in economic damages, while economic damages from the 2019-20 wildfires in Australia reached USD 23 billion (EM-DAT, 2023[6]).

In response to the growing occurrence of extreme wildfires, countries have adapted and improved their wildfire management practices. In doing so, an overwhelming focus has been directed towards strengthening emergency preparedness and response capacities (Rodrigues et al., 2022[7]; Verkerk, Martinez de Arano and Palahí, 2018[8]). In the European Union, the EU Civil Protection Mechanism has helped countries strengthen disaster preparedness and response in times of crisis, including by co-ordinating wildfire suppression efforts and providing expertise and firefighting equipment (European Civil Protection and Humanitarian Aid Operations, 2022[9]). In an effort to detect wildfires early, countries have also improved their fire monitoring capacities. For example, the European Forest Fire Information System (EFFIS) and the Digital Earth Australia Hotspots monitoring system provide near-real time information on fire activity (EFFIS, n.d.[10]; OECD, forthcoming[11]). In Switzerland, a system of sensors provides hourly information on fuel moisture in selected forest patches (Müller, Vilà-Vilardell and Vacik, 2020[12]). Furthermore, early warning and evacuation systems have been improved in response to the gaps observed during extreme wildfires. For instance, Greece and Portugal introduced a text message system notifying anyone with cellular reception, including residents and visitors, of imminent wildfires. In Portugal, recent legislation also mandates the maintenance of ten-metre-wide buffer zones around main roads to ensure sufficiently large escape routes and access routes for firefighters (Komac et al., 2020[13]). Public budgets reflect this increase in emergency preparedness efforts. In the United States, federal funding for wildfire suppression has quadrupled, from an annual average of USD 425 million in 1985-99 to an annual average of USD 1.6 billion in 2000-19 (Roman, Verzoni and Sutherland, 2020[14]). Between 1998 and 2008, Greece doubled the public funding allocated for wildfire suppression, significantly scaling up aerial firefighting capacity (Xanthopoulos, 2015[15]; 2008[16]).

However, growing wildfire frequency and severity have shown the limits of emergency preparedness and response efforts in the context of climate change (Parisien et al., 2020[17]; European Commission, 2021[18]; Xanthopoulos, 2008[16]). Increasingly extreme wildfires have strained emergency response resources and limited their ability to contain impacts. This was observed, for example, during the extreme 2009 Black Saturday wildfires in Australia, which required more than one month of wildfire suppression to be completely extinguished (Swiss Re, 2015[19]). In 2018, the outbreak of multiple simultaneous wildfires in Greece challenged the effective deployment of firefighting resources, contributing to over 100 fatalities in Mati (Xanthopoulos and Athanasiou, 2019[20]). In light of future projected climate change, emergency preparedness spending in the Canadian provinces of Alberta, British Columbia and Ontario is expected to have to double by the 2071-2100 period to keep the current levels of success in wildfire response (Hope et al., 2016[21]).

These and other recent experiences with extreme wildfires highlight the need for a paradigm shift that brings adaptation and wildfire risk prevention efforts to the centre of wildfire management. In light of the decreasing marginal benefits of emergency preparedness spending, *ex ante* adaptation measures contain a large, untapped potential for improving countries' resilience to wildfires. This includes efforts that reduce the exposure of people and economic activities to wildfires by adapting land-use planning and building construction to growing wildfire hazard. It also includes measures to manage the landscape in a way that proactively reduces wildfire risk (e.g. fuel management, ecosystem protection, forest adaptation, etc.). This chapter assesses the degree to which countries have started to invest in wildfire risk prevention efforts.

3.1.1. Methodology

This chapter presents the findings of a cross-country comparative analysis, as well as the results of five country case studies conducted in Australia, Costa Rica, Greece, Portugal and the United States. The research focused on public policies and practices to reduce the risk of wildfires. The study sought to document, evaluate and compare countries' efforts. The main national counterparts consulted were the Ministries of Environment, with contributions from the national civil protection authorities and other key national and subnational agencies engaged in wildfire risk prevention. Annex A provides a list of stakeholders who engaged in the case study work, including through the elaboration of the case study reports, responses to the questionnaires, and participation in fact-finding interviews and fact-checking processes.

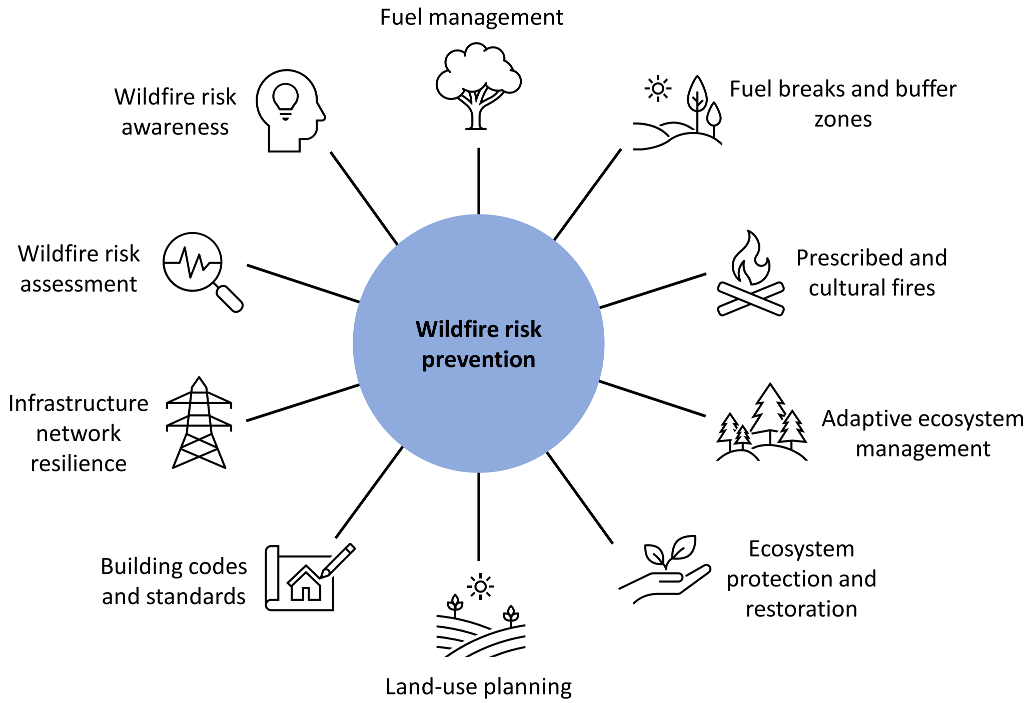
To ensure the comparability of the results of the country case studies, the background research, the country questionnaires that informed the background reports and the fact-finding missions were designed using the same structure and questions. The country questionnaire is included in Annex B of this report. The answers to these questions provide a comprehensive picture of how countries adapted their wildfire risk reduction efforts in response to the growing occurrence of extreme wildfire events.

The remainder of this chapter provides an overview of the case study findings, complemented by a review of existing policy practices around the world. It starts with an introduction of how wildfire risk prevention is fostered throughout the wildfire management cycle. It assesses countries' current efforts in wildfire risk prevention as compared to wildfire suppression. It then provides an overview of the enabling environment for wildfire management, including the financing, institutional and policy frameworks. The chapter highlights emerging good practices and identifies remaining challenges and policy gaps. The chapter's findings aims to inform policy makers and decision makers in all countries seeking to improve their wildfire risk management in the context of growing wildfire risk under climate change.

3.2. Scaling up wildfire risk prevention throughout the wildfire management cycle

In the context of growing extreme wildfire risk, scaling up climate change adaptation measures is critical to reducing the likelihood, behaviour and impacts of wildfires *ex ante* (UNISDR, 2017[22]). Wildfire prevention entails all measures that reduce wildfire hazard, as well as the exposure and vulnerability of communities and assets to wildfires, *ex ante*. Preventative measures include structural or "physical" measures that aim to manage fuel loads and continuity, such as fuel breaks, buffer zones, and prescribed and cultural fires, as well as ecosystem protection, restoration and adaptive management (see Section 3.2.1). In addition to physical measures, organisational measures are critical for reducing wildfire risk *ex ante*. These include regulations such as land-use planning or building codes and standards, as well as the fire-resilient management of infrastructure (see Section 3.2.2). Furthermore, wildfire prevention measures can also be incorporated into post-fire recovery, which plays an essential role in improving long-term resilience to wildfires (see Section 3.2.3). Wildfire prevention also entails adapting wildfire risk assessment to include expected climate change impacts on wildfire activity (see Section 3.2.4), as well as scaling up awareness-raising measures (see Section 3.2.5), which are needed if all-of-government and all-of-society are to contribute to reducing the impacts of extreme wildfires (Figure 3.1).

Figure 3.1. Reducing the risk of extreme wildfires through prevention measures



3.2.1. Fuel and ecosystem management for wildfire prevention

Fuel management is key to reducing wildfire risk and impacts, as it allows to manage the type and conditions of fuel loads in the landscape (Corona et al., 2015[23]). Fuel consists of live or dead biomass, e.g. vegetation, that is sufficiently dry to burn (see Chapter 2). Measures to manage fuel primarily include: the creation of fuel breaks and buffer zones; the use of prescribed and cultural fires ignited under safe conditions; the adaptive management of fire-prone ecosystems; and the protection and restoration of wildland ecosystems, such as forests and peatlands.

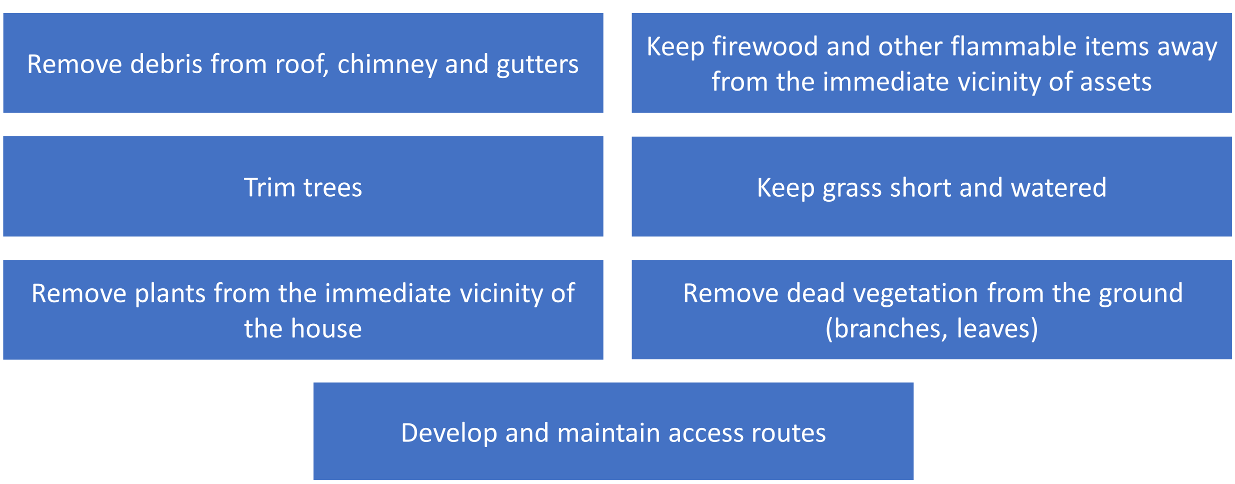
Fuel breaks and buffer zones

Managing fuel accumulation and continuity is particularly critical to reducing wildfire risk in the wildland-urban interface (WUI). Measures commonly used include buffer zones (or defensible spaces, i.e. strips of non-flammable land typically used to isolate exposed property, settlements and key infrastructure assets from flammable vegetated land) and fuel breaks, i.e. non-flammable strips of land (e.g. roads, rivers, crops, etc.) that can slow down or limit wildfire spread by breaking fuel continuity. Besides being a critical tool for wildfire prevention, these measures also facilitate emergency preparedness and response operations, as they provide evacuees and firefighters with protected corridors to transit (Rossi, Morvan and Simeoni, 2019[24]), as proven during recent extreme wildfires in the United States (US National Park Service, 2021[25]; Roman, 2018[26]).

Fuel breaks are widely used in several countries (Müller, Vilà-Vilardell and Vacik, 2020[12]; Ruiz-Mirazo, Robles and González-Rebollar, 2011[27]; Bertomeu, Pineda and Pulido, 2022[28]). In Australia and Portugal, the use of strategic networks of fuel breaks alternating different land covers (known as fuel mosaic areas) has significantly reduced landscape flammability and facilitated emergency response operations (OECD, forthcoming[29]; forthcoming[11]). Some governments have also bought private lands particularly exposed to wildfires to turn them into non-flammable fuel break areas. This occurred, for instance, in the aftermath of the extreme 2018 Camp Fire, when the municipality of Paradise, California acquired some of the most severely burned areas and transformed them into fire-resilient green spaces that serve as fuel breaks (Brasuell, 2021[30]).

The use of buffer zones to protect exposed assets and settlements is also widespread and has gained increasing attention in recent years (Roman, 2018[26]). Following particularly extreme wildfire events, both Greece and Portugal mandated the creation and maintenance of buffer areas in rural areas. In Portugal, these are mandatory for both new and existing buildings in WUI areas, while in Greece, new regulations require land tenants and owners in high-risk areas to remove excess vegetation and other flammable materials (e.g. firewood) from the perimeter surrounding their assets before the start of the wildfire season (OECD, forthcoming[29]; OECD, forthcoming[31]; Hellenic Republic, n.d.[32]). In Portugal, the Condomínio de Aldeia programme encourages fuel management in the surroundings of exposed WUI settlements and assets, promoting fire-resilient land-use changes through active land management and community engagement (OECD, forthcoming[29]; Presidency of the Council of Ministers, Portugal, 2021[33]). The programme also provides funding for managing fuel loads around properties and settlements and co-finances property owners' investments through national funding. In addition, economic incentives and government guidelines are sometimes used to encourage property owners to maintain buffer zones around their assets free from excess vegetation (e.g. by trimming trees, keeping grass short and removing plants from the immediate vicinity of the property) and other flammable fuels (e.g. debris and firewood piles) (Figure 3.2). For example, the state of Colorado, United States, offers tax incentives of up to USD 2 500 for property owners who implement prevention measures such as vegetation thinning and fuel breaks (Colorado Department of Revenue, 2022[34]).

Figure 3.2. Buffer zones and safety measures to reduce wildfire risk



Agricultural practices also play a key role in implementing fuel breaks and buffer zones. Non-flammable crops (e.g. fruit trees) can be used as fuel breaks, and agricultural practices such as grazing have also proven successful in reducing fuel loads (Ruiz-Mirazo, Robles and González-Rebollar, 2011[27]). Controlled grazing for fuel management is particularly common in Mediterranean countries such as France, Israel, Portugal and Spain (Komac et al., 2020[13]). Portugal and Spain encourage these practices through payment-for-ecosystem-services schemes, which reward local shepherds for undertaking grazing activity in public forests or around exposed settlements and assets (OECD, forthcoming[29]; Ruiz-Mirazo, Robles and González-Rebollar, 2011[27]; Varela et al., 2018[35]).

Despite their widespread uptake, the implementation of fuel breaks and buffer zones is subject to significant challenges. Local governments often lack the information and capacity to regulate, develop and maintain effective fuel break networks, as well as to enforce these requirements on private lands where regulations are in place. Land abandonment also poses significant challenges to the management of fuels on public and private lands, as it facilitates vegetation encroachment and fuel accumulation (Frei et al., 2020[36]; Moreira et al., 2020[37]; Ruiz-Mirazo, Robles and González-Rebollar, 2011[27]). Over the past century, land abandonment in the Mediterranean region has been associated with significant fuel build-up, which has contributed to an increase in wildfire risk in the region (Mantero et al., 2020[38]). This was the case, for example, in Portugal, where between 1960 and 2021 the rural population decreased from 5.7 million to 3.4 million, i.e. from 65% to 33% of the total population, leaving large portions of rural land unmanaged (World Bank, n.d.[39]; OECD, forthcoming[29]). Extreme wildfires also reduce the effectiveness of fuel breaks and buffer zones. For example, during the 2019-20 extreme wildfires in Australia, as well as during recent extreme wildfires in Andalusia, Spain, strong winds coupled with exceptionally intense wildfires allowed embers to overrun fire breaks (Nolan et al., 2021[40]).

Prescribed and cultural fires

Prescribed fires consist of small-scale, low-intensity, controlled fires ignited to achieve specific land management objectives, including wildfire prevention and ecological or agricultural management (Belcher et al., 2021[41]; Santin and Doerr, 2016[42]). In the context of wildfire prevention, prescribed fires are implemented before the start of the wildfire season to reduce fuel loads. Yet, controlled fires can also be used during the wildfire suppression phase to contain or control the spread of ongoing wildfires, a technique known as backfires. Countries such as Australia also encourage early-season prescribed fires to contain their annual wildfire-related greenhouse gas emissions, as controlled low-intensity fires release less carbon than intense wildfires occurring in the dry season (IPCC, 2022[43]; Lipsett-Moore, Wolff and Game, 2021[44]).

The extent to which prescribed fires are used for wildfire prevention varies significantly across countries (Montiel and Kraus, 2010[45]). For example, prescribed fires have been used for many decades in Australia, Canada and the United States (Burrows and McCaw, 2013[46]; Melvin, 2021[47]), while in Europe their use remains restricted (e.g. in France and Portugal) or completely forbidden (e.g. in Greece) (OECD, forthcoming[29]; forthcoming[31]; Corona et al., 2015[23]; European Commission, 2018[48]; Fernandes et al., 2013[49]). Restrictions on the use of prescribed fires usually stem from security or environmental concerns about the impact of such measure on air quality and the risk of prescribed fires slipping out of control (Huang et al., 2019[50]; USDA, 2018[51]). This high-risk perception often goes hand-in-hand with a limited awareness of the benefits of prescribed fires. To overcome these challenges, France and Portugal have recently set up specific legal frameworks to regulate active fire use, which include systems for the professional accreditation of prescribed fire managers (Montiel and Kraus, 2010[45]). The use of backfires is rather common in Mediterranean countries such as Cyprus, Portugal and Spain (OECD, forthcoming[29]; Montiel and Kraus, 2010[45]) and has recently been allowed in Greece (OECD, forthcoming[31]).

In addition to prescribed fires, other types of controlled fires on private lands can help reduce fuel accumulation and, thus, wildfire risk. These include agricultural fires ignited by farmers to regenerate crops and pastures, clear the land, and dispose of agricultural waste, as well as the cultural fires[1] ignited by indigenous groups and local communities (Box 3.1). The use of agricultural fires is regulated by national or subnational laws that define when, where and under which conditions prescribed fires can be used. In many cases, agricultural fires are forbidden during the wildfire season and can only be implemented after obtaining a permit from the relevant authorities (Müller, Vilà-Vilardell and Vacik, 2020[12]; Department of Agriculture, Food and the Marine, Ireland, n.d.[52]). To limit the use of fire for opportunistic development purposes, countries such as Ireland only allow the active use of fire on lands that will then be used for agricultural purposes (Department of Agriculture, Food and the Marine, Ireland, n.d.[52]).

However, stricter regulations on the active use of fire and better enforcement of such regulations still lack in many cases. Climate change only adds to these gaps, as longer fire seasons and less predictable weather patterns hamper the effectiveness of season-bound restrictions on the active use of fire. Besides, while regulating and restricting the use of fire in high-risk periods is critical to reducing wildfire risk, securing an ecological amount of fire activity in the landscape is important, too, to avoid the excessive accumulation of fuel. As in many cases liability concerns regarding the risk of prescribed fires slipping out of control have discouraged private landowners from using fire on their lands, some governments – e.g. the state of California – have lifted liability laws for wildfires resulting from escaped prescribed fires, thus enabling the use of prescribed fires by indigenous groups to reduce wildfire risk (OECD, forthcoming[53]; Weir et al., 2020[54]).

Box 3.1. Harnessing cultural fires and indigenous knowledge for wildfire prevention

For thousands of years, local communities and indigenous people have used fire to manage ecosystems (Christianson, 2015[55]; Firesticks, 2019[56]). Some governments have engaged with indigenous and local communities to enable and integrate the use of these practices into broader wildfire prevention plans. This has been the case, for example, in Australia, California, and the Bolivarian Republic of Venezuela (Pardo Ibarra, 2020[57]; OECD, 2021[58]). In Australia, the use of cultural fires was associated with a reduction of 50% in the area burned between 2000-06 and 2013-19 (OECD, forthcoming[11]).

At the same time, countries have also set up programmes to facilitate the integration of local and traditional knowledge into policy processes. For example, collaborations between government officials, firefighters and indigenous communities were set up in Australia and Brazil, as well as in California and Hawaii (United States), to scale up the competences of local firefighters, improving land-use planning decisions and creating participatory local fire management plans (OECD, 2021[59]; 2021[58]; Sommer, 2020[60]). In Brazil, the collaboration of government officials and indigenous people was associated with a 40-57% reduction in wildfire risk in three large territories (as compared to the years preceding the programme implementation) while also improving relations between the government and indigenous communities (FAO, 2021[61]).

Sources: Christianson (2015[55]); Firesticks (2019[56]); Pardo Ibarra (2020[57]); Sommer (2020[60]); OECD (2021[59]; 2021[58]; forthcoming[11]); FAO (2021[61]).

Adaptive ecosystem management

Active and adaptive forest management can significantly reduce wildfire risk. Planting fire-resilient species and excluding particularly fire-prone species in high-risk areas plays a key role in reducing landscape flammability and increasing vegetation resilience to wildfires (Fitzgerald and Bennett, 2013[62]). These interventions are particularly important in fire-prone areas where highly flammable non-native species prevail. For example, in Portugal, the total area of eucalyptus forests grew by 62% between 1990 and 2017 (APA, 2020[63]) and currently accounts for 26% of the total forest area of mainland Portugal, according to the country's latest forest inventory (ICNF, 2016[64]; 2021[65]; OECD, forthcoming[29]). To address this challenge and reduce landscape flammability, Portugal has established a pilot payment-for-ecosystem-services scheme that rewards private landowners who plant native species (OECD, forthcoming[29]).

Other widely used ecosystem-based interventions for wildfire risk reduction include the use of vegetation thinning, i.e. the selective removal of some parts of the vegetation to reduce excessive forest density. Forest thinning makes forest stands healthier and more resilient to wildfires (Figure 3.3) and other risks, such as pest outbreaks (Oregon Forest Resources Institute, 2023[68]). For instance, in Spain, the use of forest thinning, along with prescribed fires, has significantly reduced the wildfire spread rate and severity in forested lands (Piqué and Domènech, 2018[69]). Yet, existing land ownership structures often hamper the effectiveness of these measures (Box 3.2). Besides, in some areas (e.g. in the Alpine region), forest owners often lack the necessary awareness and skills for adaptive forest management, which can lead to inappropriate levels or types of forest management. Local governments themselves may, in some cases, lack the capacity to manage (or mandate the management of) forests in line with local ecological needs and characteristics.

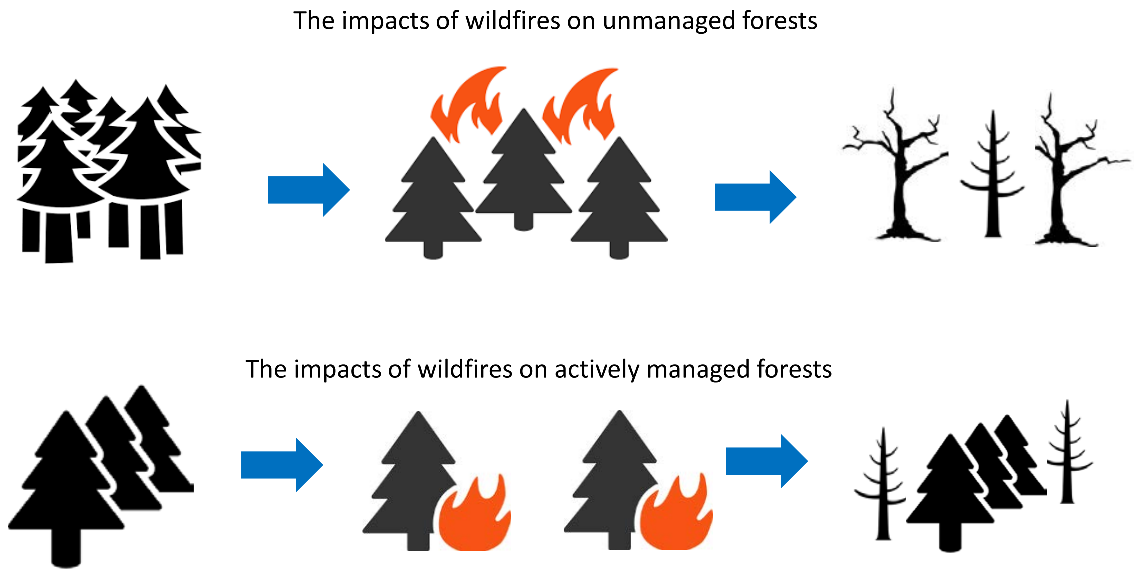
Box 3.2. Managing fuel in private lands: The challenge of land ownership

Engaging with private land owners is a critical component of wildfire prevention, as they are responsible for implementing fuel management measures on private land. This is particularly important in countries where land or forests are largely owned by private entities – such as in Portugal, where only 3% of forested land is owned by the state. Yet, in several countries, the enforcement of existing requirements concerning active forest management is challenged by unknown or unclear land ownership, which raises the question of who should manage fuel accumulation when landowners are not clearly defined. For example, in Portugal, over 20% of forestlands have no or unknown ownership and only 46% of forest areas are included in the land registry. In Greece, similar challenges are further complicated by the unclear delineation of forest areas (APA, 2020[63]; Triantis, 2022[66]; OECD, forthcoming[31]; forthcoming[29]).

To tackle these challenges, Portugal has recently passed a law that enables the state to carry out fuel management activities in forestlands where the owner is unknown or where owners fail to carry out the requested fuel management efforts, a practice known as “forced tenancy”. In addition, the Bolsa de Terras programme encourages public and private lands to be made available for lease or sale to facilitate their active management via agricultural, forestry and silvipastoral activities (OECD, forthcoming[29]).

Sources: OECD (forthcoming[29]; forthcoming[31]); APA (2020[63]); Triantis (2022[66]); The Nature Conservancy and Willis Watson Towers (2021[67]).

Figure 3.3. The benefits of active fuel management for wildfire risk reduction in forested areas



Ecosystem protection and restoration

Protecting and restoring ecosystems is critical for wildfire risk prevention. Healthy forests, peatlands and other wildland ecosystems are usually less prone to wildfire ignition and spread and more resilient to the potential negative impacts of wildfires. They also contribute to other societal goals, including the conservation of biodiversity and climate change mitigation (OECD, 2021[70]).

Ecosystem degradation, aggravated by climate change, has made many ecosystems more prone to fire. For example, forest degradation and fragmentation due to excessive logging, overgrazing and deforestation can reduce forest humidity and increase atmospheric temperature, enhancing the risk of extreme wildfires (Wester Fire Chiefs Association, 2023[71]). Peatland drainage and associated drying can also enhance wildfire risk, as dry peat is highly flammable and wildfires in peatlands can burn underground and are thus difficult to extinguish (Borneo Nature Foundation, n.d.[72]). For example, the large extent of burned area observed during the 2016 wildfires in Ghana was associated with forest degradation, which by reducing fuel moisture exacerbated the impacts of drought and contributed to the spread of the wildfire. Consequently, the extent of burned area in degraded forest stands was found to be higher than that experienced by healthier ones (Dwomoh et al., 2019[73]). Similarly, low water levels in Indonesia's degraded peatlands contributed to the occurrence and severity of the 2015 wildfires by making the landscape more flammable (UNEP, n.d.[74]).

Following particularly extreme wildfires in recent years, protecting and restoring forests and peatlands have become a key element in many countries' wildfire risk prevention efforts. Forest restoration efforts such as reforestation, tree diversity restoration, and the control of invasive and underbrush species are at the centre of wildfire risk prevention efforts in Costa Rica (Box 3.3), Gambia and South Africa (Global Canopy, 2021[75]; UNEP, UNEP-DTU Partnership, World Adaptation Science Program, 2021[76]; Republic of South Africa, 2022[77]). The United States has also recently announced a new partnership among federal and state agencies and indigenous communities to enhance nature conservation and reforestation efforts for wildfire risk reduction (Government of the United States, 2022[78]). In the aftermath of the 2015 extreme wildfires, Indonesia established an agency dedicated to peatland restoration and pledged to restore the hydrological balance of over 2 million hectares of peatland in an effort to reduce future wildfire risk and greenhouse gas emissions (Ward et al., 2021[79]; Wijaya et al., 2016[80]). Countries have also adopted strict rules to protect forests and peatlands from deforestation, degradation and land-use changes that could lead to higher wildfire risk. In the aftermath of the 2015 wildfires, Indonesia issued a permanent moratorium on primary forest and peatland conversion permits (Wijaya et al., 2016[80]), while in 2022, the United States issued an executive order to protect old-grown forests to reduce wildfire risk (Government of the United States, 2022[78]).

Box 3.3. Wildfire risk prevention in protected areas: The case of Costa Rica

Costa Rica is recognised globally for its national system of protected areas and natural parks, which cover over 25% of its continental territory. In these areas, the National System of Conservation Areas (SINAC) – i.e. the agency in charge of designing and implementing national strategies and projects in protected areas – promotes wildfire prevention by encouraging active ecosystem management. In the Palo Verde National Park, ecosystem-based interventions include the management of fuel accumulation through controlled fires, extensive grazing and the mowing of vegetation. Prescribed fires are also used every year in the Santa Rosa National Park as part of the local wildfire protection programme. In some protected areas, activities are also carried out to recover water bodies, estuaries and seasonal wetlands. In and around the territory of protected areas, SINAC also works to raise public awareness of the ecological value of protected areas and the risks posed by wildfires in the context of climate change. It also undertakes research on the fuel characteristics and wildfire drivers in Costa Rica's protected areas. Since 2013, Costa Rica has also engaged in technical studies to identify the areas projected to be most affected by wildfires under future climate change.

Sources: SINAC (n.d.[81]); MINAE (n.d.[82]); Espinoza (2016[83]).

Despite some progress, there is scope to strengthen efforts to protect and restore wildland ecosystems from unsustainable land-use practices. The lack of compliance with existing regulations is a key challenge in many of the countries suffering from high deforestation rates. For example, Brazil faces major compliance issues in the application of its national Forest Code, which requires private landowners in ecologically sensitive areas to maintain a share of their lands undeveloped (Stefanes et al., 2018[84]). Low compliance has been associated with insufficient monitoring and enforcement activities, as well as incomplete rural land registries, which in the Brazilian Amazon provide clear land ownership information for only 10% of all private lands (The Nature Conservancy, n.d.[85]).

Major policy gaps also remain in the restoration of natural fire activity, which in some areas is an important pillar of ecosystem restoration. While fire-adapted ecosystems may benefit from natural wildfire occurrence, countries often tend to favour the immediate suppression of wildfires, even in remote areas where low-intensity natural wildfires do not pose an immediate threat to communities or exposed assets. This insufficient level of natural fire activity in fire-adapted ecosystems is often linked to a lack of technical knowledge and skewed risk perception and can have long-term implications on ecosystem health and resilience to future wildfire risk (UNEP, 2021[86]). The excessive reliance on wildfire suppression has been associated with ecosystem imbalances in many areas, including in Brazil, Greece, the United Republic of Tanzania and the United States (Kelly et al., 2020[87]; Xanthopoulos, 2008[16]).

3.2.2. Land-use planning and building regulations for wildfire prevention

Land-use planning and building regulations play a critical role in wildfire risk prevention, as integrating wildfire hazard information into land-use decisions can directly reduce the exposure and vulnerability of people and assets.

Land-use planning for wildfire prevention

Land-use planning allows limiting development or mandating specific prevention measures for new and existing constructions in fire-prone areas. In particular, land-use zoning and regulations on building height and density within each land parcel can help contain wildfire risk, reducing fire spread and building resilience to wildfire impacts (Ganteaume and Long-Fournel, 2015[88]).

Land-use zoning informed by wildfire risk assessments (see Section 3.2.4) has been widely used to reduce human and asset exposure to wildfire risk. For example, in Portugal, the construction of new permanent buildings is forbidden in areas characterised by "high" and "very high" wildfire hazard (OECD, forthcoming[29]; Presidency of the Council of Ministers, Portugal, 2021[33]). Exceptions to this ban are only granted in specific cases and when risk reduction measures, such as buffer zones, are implemented. In France, wildfire risk prevention plans regulate development in fire-prone areas, banning development in areas where property protection is impossible and only allowing it where exposure and vulnerability can be reduced via specific wildfire risk reduction measures, such as the use of fire walls or non-flammable building materials (Kocher et al., 2017[89]).

Nonetheless, due to high demand for residential and touristic development, asset construction in the WUI continues to grow in several countries. For example, between 1990 and 2010, the WUI area and population in the United States increased by 33-34%, contributing to the devastating wildfire impacts observed in recent years (Radeloff et al., 2018[90]). These trends, which are particularly common in coastal areas or metropolitan areas expanding into fire-prone areas, only exacerbate the low planning and enforcement capacity that characterises some local governments. In Greece, high development demand in the WUI combined with unclear land type categorisation have facilitated informal housing development in high-risk areas, with an average of 31 000 informal buildings built illegally every year between 1991 and 2001 (i.e. one-quarter of total development occurred in the country in the same period) (Blandford, 2019[91]; Triantis, 2022[66]). During the extreme Mati wildfires in 2018, the high number of assets that did not have building permits contributed to the severity of the fires, resulting in a building destruction rate of 80% (Hellenic Republic, 2021[92]; Blandford, 2019[91]; OECD, forthcoming[31]).

Building codes and standards for wildfire-resilient assets

Building codes and standards regulate how physical assets such as houses and infrastructure should be built or managed. For example, they can mandate the use of non-flammable materials for buildings and fences or the upgrade and maintenance of assets using hard reinforcement and defensive measures (e.g. requirements on the fireproofing of windows, vents, chimneys, etc.) (Figure 3.4). Altogether, these practices are particularly effective in reducing the likelihood of assets being burned, as in many cases buildings are ignited by flying embers rather than by direct contact with the wildfire itself (Insurance Institute for Business & Home Safety, 2019[93]). A recent study suggests that structural improvements alone can reduce wildfire risk by up to 40%, reducing losses by five times compared to highly flammable structures (Czajkowski et al., 2020[94]). This was demonstrated during the 2018 Camp Fire in California, when only 11.5% of older houses (i.e. houses built before 1990) survived the fire, while 44% of the houses built after 2008 (i.e. a year in which stricter building regulations were implemented) survived the fire (Knapp et al., 2021[95]). Similarly, during the extreme Attica fires in Greece, the village of Neos Voutzas – a highly exposed settlement mostly built out of high-quality building materials – suffered limited damage, while in the neighbouring village of Mati, 80% of constructions were completely destroyed (Hellenic Republic, 2021[92]; OECD, forthcoming[31]).

Figure 3.4. Building reinforcement options for wildfire-resilient housing

Source: Based on Lynch, McMahon and Sassian (2019[96]).

Building codes and standards are used to contain wildfire impacts and costs several in high-risk areas. Legislation mandating structural protection measures and fire-proof building design, including the use of non-flammable materials and non-flammable roofs and fences, is in place in Greece and Portugal (OECD, forthcoming[29]; forthcoming[31]; Hellenic Republic, n.d.[32]). In New Zealand, the national government implemented building regulation clauses to limit the spread of wildfires and ensure the structural stability of buildings during wildfires (Government of New Zealand, 2021[97]). In California, new assets built in fire-prone areas are subject to building code requirements, including on defensible space and construction materials and methods (ICC Digital Codes, n.d.[98]; OECD, forthcoming[53]). Besides, in the United States, the application of the International Wildland-Urban Interface Code (IWUIC),[2] a model code designed to support land development regulation in the WUI, is mandatory for every new federal building of a certain size built in WUI areas (US Fire Administration, 2016[99]; OECD, forthcoming[53]). In Australia, voluntary best-practice guidelines on wildfire-resilient construction are also in place (OECD, forthcoming[11]). In Boulder County, Colorado (United States), the local government funds house inspections that provide tailored recommendations for risk prevention measures that can be adopted at the property level (e.g. fire-proof roofs and windows, non-flammable building materials, buffer zones). Property owners who implement these measures receive certificates that enable them to get insurance coverage for wildfire risk (Boulder County, n.d.[100]; Kunreuther and St. Peter, 2020[101]).

However, despite recent improvements, the development and implementation of building regulations are still limited. In many cases, existing building codes and standards only apply to new developments, leaving a regulatory gap for buildings and assets that already exist in high-risk areas. Besides, building codes and standards are sometimes developed in the form of non-legally binding guidelines to be adopted on a voluntary basis. Besides, in some cases, subnational governments lack the capacity to develop fire-resilient land-use and building regulations. To address this challenge, in Colorado, programmes are in place to encourage the integration of risk reduction measures into county-level land-use and building regulations (Planning for Hazards, n.d.[102]). In addition, where building codes exist, their enforcement remains a key challenge (IBHS, 2019[103]), mostly due to limited monitoring capacity and resources at the local level. To tackle low compliance with existing building regulations, some local governments in Oregon, United States, have set up fines for non-compliance (Roman, 2018[26]).

Infrastructure design, operation and management

Infrastructure managers and operators can play a key role in wildfire risk prevention. While wildfires can have negative impacts on infrastructure by destroying or damaging exposed assets and interrupting infrastructure services (see Chapter 2), poorly planned or managed infrastructure in WUI areas can, in turn, increase wildfire risk (IPCC, 2022[43]). In many cases, infrastructure such as railways and electricity lines represent a key cause of wildfire ignition. For example, in California, utility failures caused the ignition of 40% of the most destructive wildfires in the state's history, including the devastating 2018 Camp Fire (Legislative Analyst's Office, 2021[104]). Five of the ten wildfires that caused the most destruction in California between 2015 and 2019 were linked to failures in the electrical network of one single energy utility, whose assets were found to be in a state of neglect and did to meet state requirements on infrastructure maintenance (Penn, Eavis and Glanz, 2019[105]). As conditions conducive to extreme wildfires grow in the context of climate change, similar events only become more likely, making climate-resilient infrastructure design and management ever more crucial to reduce wildfire risk (Lyster, Farber and McFadden, 2022[106]). At the same time, it is essential to build critical infrastructure networks that are resilient to current and future wildfire risk, ensuring that their services and operations continue running as much as possible even during wildfire events (OECD, 2019[107]).

To build infrastructure resilience to wildfires, countries have adapted regulations mandating infrastructure operators to abide by safety rules and develop contingency plans that can reduce wildfire risk and impacts. For example, Canada requires its two largest train companies to reduce train speed during high wildfire risk periods, as well as to remove flammable materials from the tracks and prepare their own wildfire risk reduction plans (Scherer, 2021[108]). In addition, some national and subnational governments set specific programmes and targets to ensure wildfire-resilient infrastructure development. Following the extreme 2009 wildfires, the state of Victoria, Australia, established an AUD 750 million Powerline Bushfire Safety Program, which has reduced wildfire risk from powerline ignition by upgrading the electricity distribution network and regulating infrastructure management in high-risk areas (OECD, forthcoming[11]; Victoria State Government, 2022[109]). In Portugal, the Climate Change Adaptation Action Plan sets the ambition to have 50% of its transport infrastructure companies develop an adaptation or contingency plan for extreme events by 2030 (OECD, forthcoming[29]). Furthermore, infrastructure project plans in Portugal must consider climate scenarios to be approved and, in most cases, critical infrastructure managers are legally required to manage wildfire risk around their assets (OECD, forthcoming[29]).

Infrastructure managers and operators have also taken voluntary measures to reduce wildfire risk. For example, Portugal's largest generator and provider of energy, Energias de Portugal, has developed its own wildfire hazard reduction plan, which includes interventions on fuel management, asset management, wildfire surveillance and awareness-raising activities. Since 2013, the plan has contributed to reducing the burned area in Sabor Valley from an average of 210 hectares per year to 14 hectares per year (UNDRR, 2021[110]). In Southern California, San Diego Gas & Electric, a public utility provider, has installed additional weather stations, cameras and other technology to monitor real-time wildfire risk and adapt operations accordingly (Penn, Eavis and Glanz, 2019[105]). Overall, while regulations that require infrastructure managers and operators to abide by certain safety rules are in place in some cases, in many countries such measures are implemented on a voluntary basis.

3.2.3. Mainstreaming wildfire prevention in post-fire recovery measures

The period following a destructive wildfire offers a window of opportunity to integrate risk prevention considerations into recovery efforts and build long-term resilience (Schumann et al., 2020[111]). Indeed, the policy and management decisions taken in the aftermath of a wildfire can affect future wildfire hazard as well as the exposure and vulnerability of communities and assets to future wildfire risk (Pacheco and Claro, 2020[112]). Post-fire recovery encompasses all the rehabilitation, restoration and reconstruction interventions that take place after a wildfire, including both short-term efforts to stabilise the emergency and long-term interventions aimed at the recovery of ecosystems and socio-economic assets and systems.

Emergency stabilisation

Emergency stabilisation efforts are undertaken immediately after a wildfire to contain damage and prevent cascading risks and impacts to life and ecosystems, as well as to socio-economic and cultural assets (Pacheco and Claro, 2020[112]; US Forest Service, 2021[113]). Stabilisation interventions can focus on reducing the risk and impacts of post-fire soil erosion, landslide or water contamination (UNEP, 2021[86]) as well as on restoring critical infrastructure and basic services, such as transport or electricity networks. Emergency stabilisation interventions usually focus on severely burned areas, as well as on areas considered particularly vulnerable to negative post-fire risks and impacts, such as erodible steep slopes or river catchments and critical infrastructure downstream (Cerdà and Robichaud, 2009[114]).

In many countries, emergency stabilisation is considered the key priority after a wildfire has been extinguished, as the timeliness of such interventions is critical to ensure their effectiveness. This is the case in the United States, where after a wildfire the Forest Service's Burned Area Emergency Response prioritises the stabilisation of burned lands, e.g. through the modification of drainage systems to reduce debris flow risk and the plantation of quick-growing species for hillslope stabilisation, erosion and water pollution control (OECD, forthcoming[53]; USDA, n.d.[115]). Similarly, in Chile and the United Kingdom, the treatment of burned hillslopes has been used to prevent soil erosion (Robinne et al., 2021[116]; van Hensbergen and Cedergren, 2020[5]). To contain risk, Portugal also uses fuel breaks to isolate the areas where extinguished fires could likely reignite, a practice known as rekindle control. Increased efforts in rekindle control reduced the total area burned by rekindle fires eightfold between 2001-17 and 2018-21 (from 13 000 hectares per year to 1 500 hectares per year) (ICNF, 2022[117]).

Ecological restoration

Ecological restoration measures aim to rehabilitate landscapes, natural resources and ecosystems by restoring natural biophysical processes. They can include the reforestation of burned areas, the restoration of native habitats, the treatment of invasive species, and the removal of dead biomass (Valderrama, Contreras-Reyes and Carrasco, 2018[118]). By intervening on fuel types, conditions and continuity, these interventions can significantly affect long-term landscape resilience to wildfire risk – as proven by the recent restoration of native cork oak belts in Algarve, Portugal, which contributed to reducing landscape flammability and protecting ecosystem structure and functioning (UNEP, 2022[119]). In the United States, efforts are also in place to support tree cover restoration capacity (e.g. through the Emergency Forest Restoration Program as well as seed collection and nurseries) in the aftermath of extreme wildfires (OECD, forthcoming[53]; Government of the United States, 2022[78]).

The extent to which post-fire recovery efforts are needed varies significantly. Fire-adapted ecosystems usually recover naturally following a wildfire. Yet, the growing occurrence of extreme wildfires, and most notably the outbreak of wildfires in non-fire-adapted ecosystems, hampers ecosystems' natural recovery capacity, in extreme cases leading to vegetation cover shifts (Turner et al., 2019[120]; Stevens-Rumann et al., 2018[121]) (see Chapter 2). Thus, human intervention can often help nudge the recovery process (e.g. planting trees or treating the soil) or protect ecosystems during the delicate recovery phase (e.g. against overgrazing, invasive species and deforestation) (UNEP, 2021[86]; Müller, Vilà-Vilardell and Vacik, 2020[12]). Countries such as Australia, Costa Rica and Greece have taken steps to enhance their understanding and management of post-fire ecosystem recovery needs. In Australia, after the 2019-20 extreme wildfire season, an expert panel was set up to assess wildfire impacts on native species and how to support their recovery (OECD, forthcoming[11]). After the Evia extreme wildfire in 2021, Greece took steps forward in this direction by developing the Greek Biodiversity Restoration Hub, which sets a framework for improving ecosystem recovery in burned areas through expert support, enhanced monitoring and co-ordination (OECD, forthcoming[31]; Biodiversity Recovery Hub, 2022[122]). After each wildfire, Costa Rica develops a plan for ecosystem restoration, considering both passive and active recovery options based on assessments of local ecological dynamics and conditions.

The lack of information, capacity and resources can hamper effective landscape recovery after a wildfire, often leaving ecological recovery unmanaged and unmonitored (OECD, forthcoming[31]; forthcoming[29]). This is particularly challenging on private lands, as site rehabilitation usually falls under the responsibility of the relevant landowner (Box 3.2) (OECD, forthcoming[53]). The lack of careful assessments of ecosystem recovery ability and needs can also lead to poorly adapted interventions as well as to failures to preserve ecologically functional levels of fire activity, which risks increasing wildfire risk in the long run (Schumann et al., 2020[111]). Besides, in some areas, opportunistic post-fire land grabbing poses another major challenge to effective and fire-resilient post-fire restoration (WWF, 2020[123]).

Asset recovery and reconstruction

Post-fire interventions also include measures focused on the recovery and reconstruction of damaged or lost assets and settlements. The reconstruction phase offers an opportunity to rethink and redesign the interface between human settlements and wildfire activity and to build back better, e.g. using zoning tools, fuel breaks, or building codes and standards (see Section 3.2.2). For example, in the aftermath of the extreme Camp Fire in 2018, the municipality of Paradise, United States, bought the properties located near the perimeter of the fire to turn them into fire-resilient green spaces that can act as fire breaks in the occurrence of a new wildfire (Brasuell, 2021[30]).

Major gaps remain in the development of more resilient built landscapes in the post-fire phase. Indeed, under pressure to "quickly return to normal" after a wildfire, fire-resilient land-use and building regulations often fail to be considered. For instance, in Colorado, United States, post-fire recovery efforts after the 2010 and 2012 wildfires were found to not have improved resilience to wildfires (Mockrin et al., 2016[124]). While some property owners improved building conditions and enhanced vegetation management around their properties to reduce future wildfire risk, local governments were not found to have substantially revised building and land-use standards (Mockrin et al., 2016[124]). In some cases, failure to build back better is linked to difficulties in enforcing wildfire policies at the local level (Hui et al., 2021[125]). For example, in the aftermath of the extreme Mati wildfire in Greece, local groups opposed the widening of the local street network, even though the narrow streets and absent escape routes in the WUI contributed to the high death toll (Triantis, 2022[66]). Finally, when settlement relocation is identified as the best policy option available, the socio-economic implications of such decisions also pose major challenges to their uptake. Evidence from the 2005 wildfires in the Eyre Peninsula, Australia, indicates that besides the traumatic experience of experiencing a wildfire, post-fire relocation was found to further increase the likelihood of post-traumatic stress disorder in survivors (Watts et al., 2023[126]).

3.2.4. Informing wildfire prevention: The role of wildfire risk assessment

Wildfire hazard assessment and risk information provide the foundation for all wildfire risk prevention and preparedness decisions. By providing estimates on the spatial and temporal occurrence of wildfires, risk assessments provide the critical evidence base to inform long-term risk prevention measures and interventions in the aftermath of a wildfire (Scott, Thompson and Calkin, 2013[127]; UNISDR, 2017[128]). For example, risk assessments can inform decisions on where and how to build new assets or develop certain activities (UNISDR, 2017[128]). Wildfire risk assessments consist in the identification and estimation of current and future wildfire risk by assessing potential hazard and the existing exposures and vulnerabilities that combined could generate negative impacts on people, property, services, the environment and the economy (Table 3.1) (IPCC, 2022[129]; UNISDR, 2017[128]; OECD, 2017[130]).

Table 3.1. The three steps in wildfire risk assessment

Step	What is assessed	How it is assessed
Hazard assessment	Potential for harmful wildfire occurrence and behaviour (e.g. likelihood, frequency, magnitude, spread, duration and intensity)	Gather, model and map information on fuel loads, continuity and conditions (e.g. moisture); atmospheric conditions (temperature, drought, precipitation, wind, lightning); topography; causes of ignition; assess linked hazards and potential cascading impacts
Exposure assessment	Presence of people, ecological, socio-economic assets and ecological systems in or close to wildfire-prone areas	Combine information on wildfire hazard with the spatial location of people and valued resources, activities and assets (e.g. housing, infrastructure, production capacities)
Vulnerability assessment	The characteristics of people, communities, ecosystems, assets and systems that make them prone to be adversely affected by wildfires	Susceptibility and fragility of people, ecological and socio-economic assets; capacity of humans, physical assets, and socio-economic and environmental systems to cope with and recover from wildfire events

Source: Based on JRC (2022[131]) and UNISDR (2017[128]).

Wildfire hazard modelling is the first step in wildfire risk assessment. Wildfire hazard modelling allows estimating future wildfire occurrence (i.e. likelihood and frequency) and behaviour (i.e. the way wildfires ignite and spread) (Müller, Vilà-Vilardell and Vacik, 2020[12]) based on a wide array of geophysical information including, for example, data on vegetation cover, landscape characteristics (e.g. slope, elevation), climate and weather patterns, as well as historical wildfire and weather records (Scott, Thompson and Calkin, 2013[127]; UNISDR, 2017[128]). In some cases, wildfire models also build on existing simulations of vegetation cover change and fire-atmospheric and fire-vegetation feedback interactions. All this information can be represented spatially in the form of wildfire hazard maps, which represent a key tool for grasping and communicating the spatial distribution of wildfire hazard to relevant stakeholders.

Countries widely use wildfire hazard modelling and mapping, and recent technological and scientific developments have allowed major advancements in this domain. In Austria, the current hazard models combine information on vegetation cover, topography and potential wildfire drivers (Müller, Vilà-Vilardell and Vacik, 2020[12]). In the United States, the accuracy of existing models on wildfire occurrence and spread, fire-atmospheric feedbacks, as well as smoke spread, soil heating and moisture evaporation during a wildfire has significantly improved (USDA, n.d.[132]; USGS, 2020[133]; NIST, 2021[134]). Building on wildfire hazard models, countries such as Portugal and the United States have developed national and subnational wildfire hazard maps that classify the territory by hazard level (USDA, n.a.[135]; DGT, n.a.[136]; OECD, forthcoming[53]). In Portugal, in addition to the national hazard map, each municipality is also required to have a wildfire hazard map that is updated every ten years (OECD, forthcoming[29]). In Slovenia, hazard assessments are carried out at the regional level based on the methodology prescribed by the national government (Müller, Vilà-Vilardell and Vacik, 2020[12]). Despite significant improvements, some challenges remain. Persisting gaps in data availability and quality (e.g. on fuel cover) and knowledge gaps on the complex interactions of different wildfire drivers (e.g. fire-vegetation and fire-weather feedback), along with limitations in the wildfire models' predictive capacity, limit the comprehensiveness of existing projections (OECD, forthcoming[29]; forthcoming[31]). Furthermore, increasingly sophisticated hazard models also require high-resolution, up-to-date spatial information (e.g. on available fuel and weather conditions), which can be very resource intensive.

Wildfire hazard assessments need to be integrated with spatial information on the exposure and vulnerability of human and ecological systems (Scott, Thompson and Calkin, 2013[127]). Yet, in most cases, the integration of socio-economic information into wildfire risk assessments remains a challenge due to the persisting gaps in the availability of data on wildfire exposure and the unavailability of impact assessments to estimate the vulnerability of people and assets (Jacome Felix Oom et al., 2022[131]). Wildfire risk maps exist at the national level, as well as in some states, in the United States (FEMA, n.d.[137]; Oregon Department of Forestry and US Forest Service, n.d.[138]). In Italy, some efforts have been made at the regional level to integrate data on the exposure of people and assets with hazard maps (Müller, Vilà-Vilardell and Vacik, 2020[12]). However, in most countries, risk maps are currently not available (OECD, forthcoming[31]; forthcoming[11]; forthcoming[29]). Some good practices have emerged to address these challenges. In Portugal, efforts are underway to develop a nationwide wildfire risk map, as the absence of such tool was identified as a key challenge to effective wildfire management (OECD, forthcoming[29]). In Greece, the region of Attica has carried out a comprehensive wildfire risk assessment considering hazard, vulnerability and exposure in selected high-risk areas, with projections available at the neighbourhood level (OECD, forthcoming[31]).

To effectively assess wildfire risk, it is important to account for the effects of climate change on the weather, fuel and ignition patterns that determine wildfire risk (UNISDR, 2017[22]). Climate change has already altered atmospheric temperatures, precipitation, lightning and wind patterns, the occurrence of heat and drought extremes, and changes in vegetation cover. These changes are projected to continue under future climate change, further affecting fire weather, fuel conditions and ignition likelihood (see Chapter 2). Hence, considering the impacts of future climate change in wildfire hazard models is critical (Vilar et al., 2021[139]; IPCC, 2020[140]). Yet, climate change projections often fail to be integrated into wildfire models and broader risk assessment efforts. For example, while wildfire risk projections exist in Portugal, they are not integrated into existing risk assessment and planning processes. The Portuguese Environment Agency is currently working on updating the downscaled projections of climate-induced wildfire risk and providing guidance on how to best integrate them into risk maps and other planning instruments in the National Roadmap for Adaptation 2100 (OECD, forthcoming[29]). Overall, while research on how different climate scenarios affect fire weather indices in southern Europe has significantly advanced (Camia, Liberta and San Miguel Ayanz, 2017[141]), further efforts are needed to better reflect emerging scientific insights on the links between climate change and future wildfire activity in wildfire risk assessments.

In addition to the limited consideration of climate change impacts on wildfire activity, other challenges in wildfire risk assessment remain. Limitations in the availability and quality of historical wildfire records, including inconsistencies within and across datasets, can hamper the predictive capacity of wildfire models (Filkov, Duff and Penman, 2018[142]; Artés et al., 2019[143]; Hincks et al., 2013[144]). Modelling and mapping wildfire risk at the subnational level also remains a challenge, as it requires disaggregated data as well as appropriately downscaled models – two elements that often lack (Loureiro and Barreal, 2015[145]). In countries where wildfire risk assessment is undertaken at the subnational level, such as Italy, the lack of a national standardised risk assessment methodology also poses consistency challenges (Müller, Vilà-Vilardell and Vacik, 2020[12]). Furthermore, while more advanced models have emerged that allow accounting for changing conditions in wildfire projections, these are not yet widespread in public administrations (Box 3.4) (Müller, Vilà-Vilardell and Vacik, 2020[12]). Finally, while improving scientific and technical knowledge and data availability have increased model accuracy, a level of uncertainty on existing projections remains (Scott, Thompson and Calkin, 2013[127]; PreventionWeb, n.d.[146]).

Box 3.4. Adapting wildfire hazard modelling in the context of climate change

Data on past wildfire events are key to informing and refining wildfire hazard models, as they allow to understand wildfire trends and characteristics over time in specific areas (Hincks et al., 2013[144]). Today, several countries and organisations regularly record information on past wildfire events, some of which is publicly available (Table 3.2).

Table 3.2. Examples of databases and portals on past wildfire events

Wildfire database	Geographical coverage	Type of information
European Forest Fire Information System (EFFIS)	40+ European, Middle East and North African countries	Number of fires, burned area, maps, satellite information, historical information on meteorological conditions and fire danger for individual countries, long-term weather forecasts. Data on individual fires and reports after each fire season at the country level.
United States Geological Survey (USGS) database	United States	Area burned, ignition dates, fire causes for wildfires that occurred between 1878 and 2019.
Swissfire	Switzerland	Fire outbreak, vegetation, fire causes, burned area, fire type, firefighting efforts, weather data, land use, population density.
Fire Climate Change Initiative	Global	Burned area, wildfire impacts (e.g. air quality, carbon emissions) from 1982 onwards.
Global Wildfire Information System	Global	Brings together existing information sources at national and regional levels, information on fire regimes.
Global Fire Emissions Dataset	Global	Satellite information on fire activity, vegetation productivity, monthly burned area, fire emissions.

In the context of current climate and land-use changes, past wildfire trends do not necessarily reflect future wildfire activity (Hincks et al., 2013[144]). Hence, past data alone are not sufficient to effectively assess future wildfire risk (PreventionWeb, n.d.[146]). To address these limitations, new wildfire hazard models have emerged that integrate historical wildfire records with other possible simulated events that have not occurred but could potentially occur based on the theoretical and empirical knowledge at hand. By doing so, these models (known as probabilistic models) allow accounting for changing conditions, overcoming the limitations of projections that solely rely on historical records, and eventually delivering a more comprehensive picture of all potential future wildfire events. The results of these probabilistic models are provided through different scenarios – each associated with an estimated likelihood of occurrence (PreventionWeb, n.d.[146]).

Sources: EEA (2021[147]); EFFIS (n.d.[10]); ESA (2021[148]); GFED (n.d.[149]); GWIS (n.d.[150]); PreventionWeb (n.d.[146]); SwissFire (n.d.[151]); Welty and Jeffries (2020[152]); Hincks et al. (2013[144]).

3.2.5. Building resilience to wildfires by raising awareness

A good understanding and perception of risk levels and potential exposures are essential to enable all stakeholders to take appropriate risk reduction measures to reduce or prevent their own risk and the risks that their activities could generate for others (OECD, 2016[153]; Wilson, McCaffrey and Toman, 2017[154]). Awareness-raising efforts can take many forms, including sharing risk information in ways that are easily accessible, developing education and training programmes, and sharing knowledge and information on good practices to reduce risk (OECD, 2016[153]).

Risk communication and awareness-raising activities for wildfire risk have mostly been spearheaded by civil protection agencies, fire services, meteorological institutes and local governments (OECD, forthcoming[31]; forthcoming[53]; forthcoming[29]). Particularly extreme wildfires in recent years have raised policy makers' awareness of the existing gaps in wildfire risk communication. As a result, several large-scale risk communication campaigns have been launched (Table 3.3). Portugal's Safe Village Safe People programme promotes awareness of good behaviours to reduce and prepare for wildfire risk in rural areas. In the United States, the Colorado Wildfire Risk Public Viewer portal provides easily accessible information for landowners on the wildfire risk their properties are subject to (Colorado State Forest Service, n.d.[155]). Education programmes in schools and communities have also been developed to scale up wildfire risk awareness. For instance, local schools in Jamaica have partnered with the national Fire Brigade to raise school children's awareness of wildfire risk (FEMA, 2010[156]).

Table 3.3. Examples of existing awareness campaigns

Initiative	Country	Description
Firewise	United States	Informs individuals, particularly homeowners, about wildfire risk, suggests steps to reduce wildfire risk for properties and communities, e.g. via media channels, education tools and an information website
Portugal is Calling (Portugal Chama)	Portugal	Informs private and public stakeholders on appropriate behaviour to prevent wildfires and what to do in the event of a wildfire, e.g. via billboard campaigns and media messages
Safe Village Safe People (Aldeia Segura Pessoas Seguras)	Portugal	Promotes good practices to reduce (and prepare for) wildfire risk in fire-prone areas, targeted particularly at local communities in rural and wildland-urban interface areas, e.g. via information posters and videos on self-protection measures, training programmes and information events
FIRELIFE	Hungary	Raises awareness of wildfire risk among the public (e.g. using poster and billboard campaigns and education activities in schools) and trains professionals (e.g. farmers, foresters, firefighters) on how to reduce wildfire risk

Sources: National Fire Protection Association (2021[157]); Portugal Chama (n.d.[158]); AGIF (n.d.[159]); ANEPC (2018[160]); European Commission (2019[161]).

To enhance the reach and inclusiveness of awareness-raising efforts, programmes and campaigns are increasingly well-targeted to specific audiences. Providing information in multiple languages has helped raise awareness in highly touristic areas as well as in areas characterised by a multilingual population. As perceived gender roles were also found to influence risk perception, Australia developed its Gender and Emergency Management Guidelines, which promote the use of gender-specific messaging in risk communication (Australian Government, 2016[162]; OECD, forthcoming[11]). However, further efforts are needed to raise public awareness of wildfire risk and stimulate the uptake of risk prevention measures by private stakeholders (Ganteaume et al., 2021[163]). This is particularly challenging as risk perception and engrained behaviours that can influence risk levels are difficult to shift.

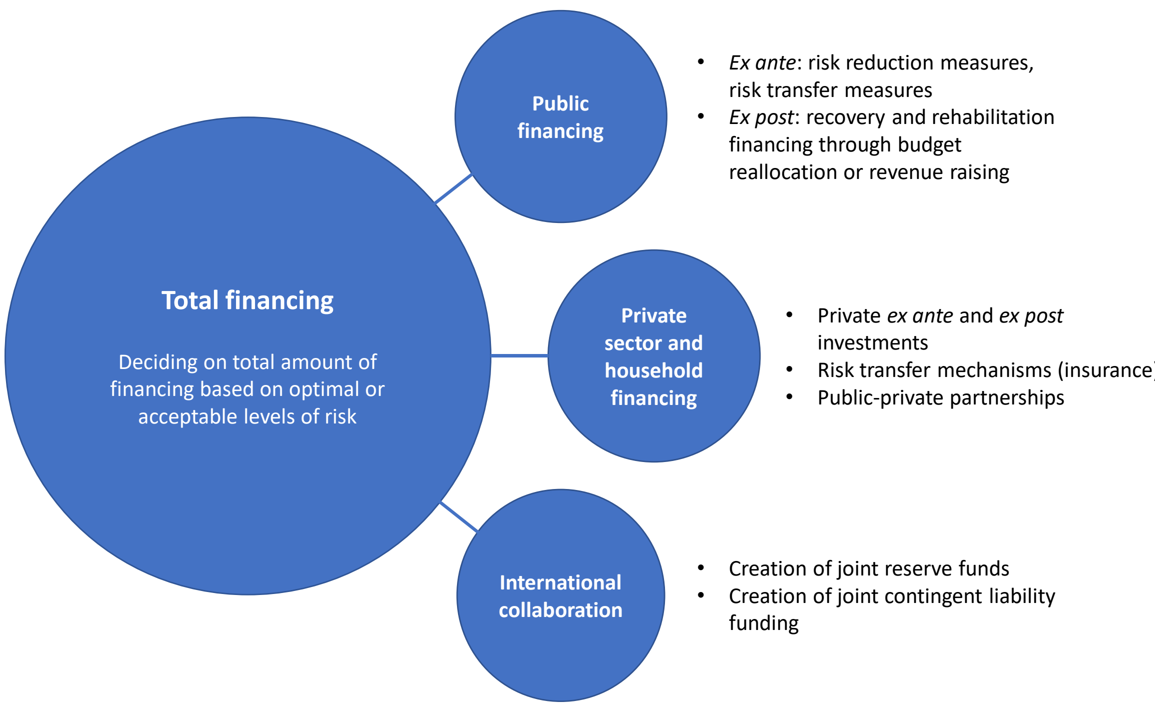
3.3. Financing wildfire risk prevention

3.3.1. Public funding for wildfire management: The need for a paradigm shift

In light of the growing wildfire risk, securing sufficient and stable funding for wildfire management is critical to build long-term resilience. To date, a large share of the funding for wildfire risk management comes from public budgets (Swiss Re, 2015[19]). While funding structures vary significantly across countries, funding for wildfire management is typically provided through a combination of local, state and national governments and agencies. For example, in the United States, the bulk of funding for wildfire management is provided by the Forest Service and the Department of the Interior and complemented by state and local budgets (OECD, forthcoming[53]; Congressional Research Service, 2021[164]).

Deciding on wildfire risk financing entails making important trade-offs. The disruptions caused by extreme wildfires have an impact on individual households, businesses and the public sector alike. Hence, all actors have to decide to which degree and how they will invest in reducing risk exposure and to which extent they choose (or are obliged to, given budget constraints) to retain risk. Governments usually face three challenges when designing their wildfire risk financing strategies. The first entails determining the overall amount of resources to be allocated to wildfire risk management and the level of risk they choose to retain. The second consists in choosing how to finance risk management. Indeed, governments have several instruments at their disposal, each of which entails different distributional effects. Finally, a third challenge lies in leveraging the participation of the private sector and individual households in financing resilience measures or investing in risk transfer arrangements, to avoid governments from having to shoulder the entire burden of disruptive shocks. Collaboration with other countries can also contribute to jointly financing risks (Figure 3.5) (OECD, 2014[165]).

Figure 3.5. A risk financing strategy mix involving public and private funding and international collaboration



Source: Adapted from OECD (2014[165]).

In response to growing wildfire occurrence and severity, many countries have scaled up existing funding for wildfire management. In the United States, the federal government nearly doubled its annual budget for wildfire management between 2011 and 2020, which reached about USD 6 billion in 2020 (Congressional Research Service, 2020[166]). Portugal has also significantly increased public funding for wildfire management, which grew by 120% between 2017 and 2021 (from EUR 143 million to EUR 316 million) (OECD, forthcoming[29]). In most cases, the increase in wildfire management funds has been financed by budget reallocations. In Australia, a large share of the funding is generated through insurance premiums. For instance, in New South Wales, a tax on insurance premiums provides almost three-quarters of the state's Fire and Rescue service, with the remainder funded by the federal, state and local governments (OECD, forthcoming[11]). Property taxes are used for similar purposes in the state of Victoria (Swiss Re, 2015[19]). Many governments also use emergency mechanisms such as contingency and reserve funds, i.e. public funds that allow governments to address exceptional emergency response costs, to fund wildfire management. The Federal Emergency Management Agency's Disaster Relief Fund in the United States and Australia's National Disaster Relief and Recovery Arrangements have allowed financing emergency response and recovery efforts, as well as providing assistance to households and businesses affected by wildfires (Richards, 2018[167]; OECD, 2015[168]) (OECD, 2015[168]). International co-operation has also contributed to scaling up funds and capacity for wildfire prevention (Box 3.5), as well as for emergency response and recovery.

Box 3.5. Scaling up wildfire risk prevention through international co-operation

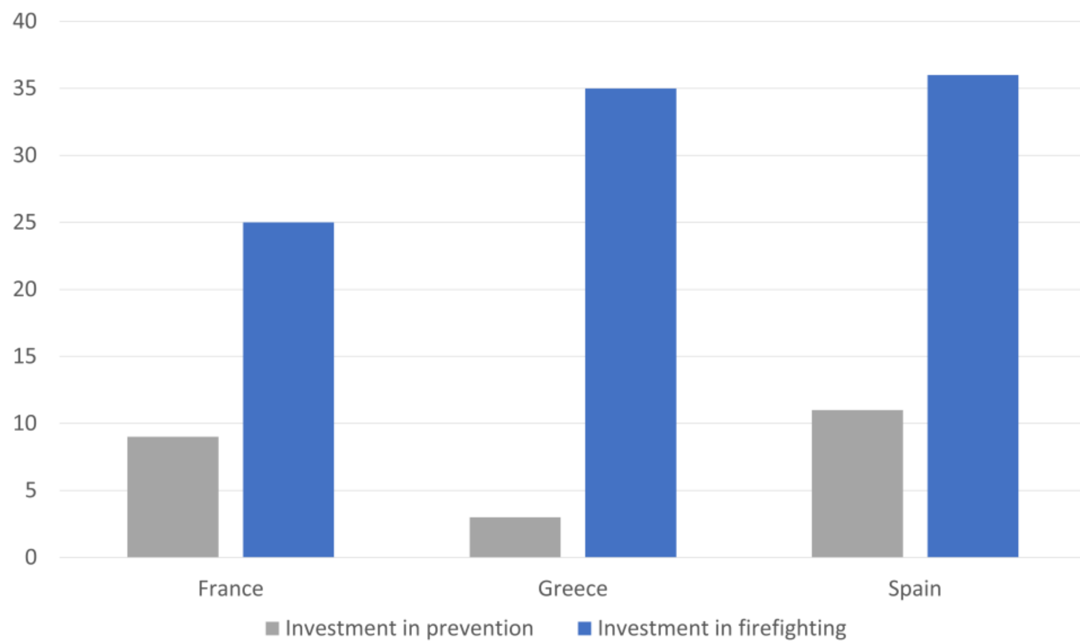
International co-operation can help ease the burden of wildfire management on individual countries' public expenditures. Successful bilateral agreements and partnerships to enhance wildfire prevention are in place between Canada and the United States as well as between Australia and New Zealand, e.g. through the Wildland Fire Management Canada-United States Program, the Trans-Tasman Fire and Emergency Management Forum, and the Australia-New Zealand Fire and Emergency Services Authorities Council. Besides, several international agreements and efforts have emerged to enhance cross-border and mutual support in wildfire risk assessment, fuel management, fire monitoring and capacity building. In Europe, the European Regional Development Fund provides funding for rural development projects, including fuel management activities. The European Union's Horizon 2020 programme provides funding for research and innovation in fuel management and other activities. In addition, the European Union has also provided funding for disaster recovery after extreme wildfire events, for example via the EU Solidarity Fund (European Commission, n.a.[169]). The EU Civil Protection Mechanism also contributes to strengthening wildfire prevention by facilitating co-operation across EU member states and eight other participating countries (European Civil Protection and Humanitarian Aid Operations, 2022[9]).

Sources: European Commission (n.a.[169]); OECD (forthcoming[53]; forthcoming[11]; forthcoming[31]; forthcoming[29]); European Civil Protection and Humanitarian Aid Operations (2022[9]).

While a strong recognition of the need to invest in wildfire risk prevention has emerged across countries, the increase in available funding to date has mostly been used to strengthen emergency response capacity. In many wildfire-prone countries, institutional frameworks and incentives remain heavily tilted towards emergency response and countries struggle to promote more prevention-oriented strategies (Drapalyuk et al., 2019[170]; OECD, forthcoming[53]; forthcoming[29]; forthcoming[31]; forthcoming[11]). Consequently, spending for wildfire suppression remains up to six times higher than the funds allocated for prevention (Figure 3.6). This structural funding imbalance has only been exacerbated by frequent "fire borrowing", i.e. the practice of diverting funds earmarked for wildfire prevention to fund emergency response and recovery. This practice, along with persisting budget constraints, has reduced the funds available for wildfire prevention measures, leading to a decline in the availability of resources for wildfire prevention and thus further exacerbating the gap between prevention and suppression funding (North et al., 2015[171]). For instance, due to a combination of budget constraints and reallocations, the funding allocated to the Greek Forest Service – the main entity responsible for wildfire prevention – shrunk by nearly 30% between 2010 and 2017, from EUR 116 million to EUR 83 million (GFMC, 2019[172]; OECD, forthcoming[31]). The growing costs of wildfire suppression in the context of climate and land-use changes further exacerbate this funding gap, raising concerns about the sustainability of public funding practices going forward (Saha et al., 2021[173]).

Figure 3.6. Public investments in prevention and suppression in France, Greece and Spain

EUR per forest hectare

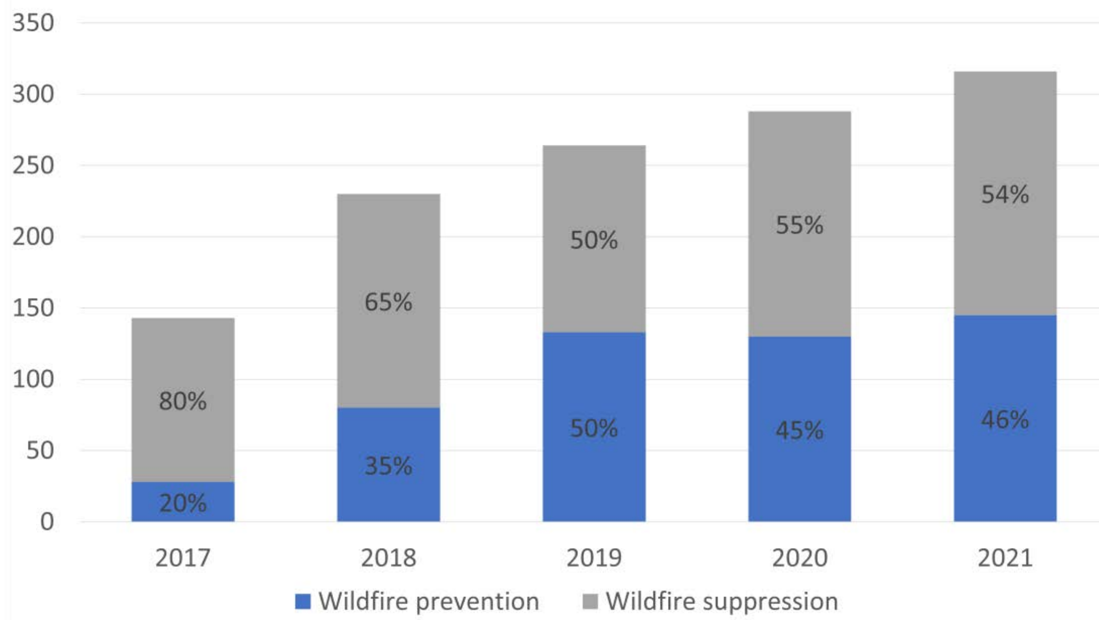


Notes: Data retrieved from WWF (2019[174]). Information on Spain is based on data from the Spanish Official School of Forestry Engineers and refers to the period 2008-17. It includes state and regional investment, as regional governments share competences in forest management. Information on France is based on data from the National Institute of Geographic and Forest Information and refers to the period 2009-18. Information on Greece is based on WWF estimations.
Source: Based on WWF (2019[174]).

Following particularly extreme wildfires in recent years, some governments have started to increase resources for wildfire prevention. In the aftermath of the 2017 wildfires, Portugal significantly boosted public funding available for wildfire prevention (Council of Ministers, Portugal, 2020[175]), bringing prevention and suppression funding to near parity. While in 2017 only 20% of wildfire management funding was allocated to prevention, by 2021 it received 46% of public funds from a greater overall budget (AGIF, 2021[176]; OECD, forthcoming[29]) (Figure 3.7). In 2022, the United States also scaled up its efforts on fuel management and prescribed fires as part of forest and landscape health management, with USD 5 billion dedicated to such measures (OECD, forthcoming[53]). Funding for wildfire prevention also increased in Greece in 2022, thanks to support from the EU Recovery and Resilience Facility, in addition to national funding efforts. As a result, EUR 72 million were allocated for the AntiNero wildfire prevention programme (Ministry of Environment and Energy, Greece, 2022[177]; OECD, forthcoming[31]). To enhance subnational governments' revenue streams to support wildfire prevention, the government of California, United States, has established a fee on properties located on state land, which is used to fund wildfire prevention in WUI areas. The government of Colorado, United States, provides application-based grants to local governments to support wildfire prevention. In 2023, these grants amounted to USD 9.5 million (Colorado State Forest Service, 2023[178]).

Figure 3.7. The shifting focus from suppression to prevention in national public funding in Portugal, 2017-21

Million EUR



Source: Based on AGIF (2021[176]).

3.3.2. The role of insurance coverage for wildfire risk

Insurance coverage for wildfire risk is important to strengthen the financial protection of private stakeholders and reduce the liability for governments that compensate for losses and damages. Insurance coverage for wildfire risk can also encourage individual wildfire risk prevention investments (OECD, 2021[179]). For example, premiums can be adjusted to reflect individual risk reduction needs, discouraging development in fire-prone lands and encouraging fire-proof development (von Peter et al., 2012[180]; Kelly et al., 2017[181]). In the United States, some insurance providers give a 5% discount on insurance premiums to homeowners that undertake certain wildfire prevention measures (Galbraith, 2017[182]). In California, the "Safer from Wildfires" programme legally mandates insurance providers to provide discounts on insurance premiums for insured individuals that undertake wildfire prevention efforts (California Department of Insurance, n.d.[183]). In some cases, insurance schemes can even require preventive measures to be adopted in order to be eligible for insurance coverage (Galbraith, 2017[182]; Chirouze et al., 2021[184]).

The extent to which insurance coverage for wildfire risk exists varies significantly across and within countries. While in some countries, such as Greece, insurance coverage for wildfire risk is part of basic property insurance coverage (OECD, forthcoming[31]), in others it remains largely unavailable in many parts of the country (OECD, forthcoming[29]). Overall, the share of wildfire losses that are insured remains relatively low across OECD countries (OECD, 2021[179]). In Greece, only around 15% of dwellings and 230 000 commercial properties have insurance coverage against wildfires (World Bank, 2021[185]), and only 9% of all wildfire losses in the country were covered by insurance between 1990 and 2019 (OECD, 2021[179]). Similarly, in Portugal, the share of wildfire losses covered by insurance was around 10% in 2021 (OECD, 2021[179]).

In some cases, the low uptake of insurance coverage for wildfire risk is also linked to the low levels of insurance availability or affordability. Increasingly extreme wildfires have posed a challenge to insurance companies' financial sustainability in some particularly fire-prone areas, leading them to pull back from the market (Golnaraghi, 2018[186]). For example, after the 2018 Camp Fire in California, insurance companies' refusal to renew insurance coverage for high-risk properties left over 340 000 properties uninsured (Moss and Burkett, 2020[187]). In other cases, growing wildfire risk has translated into unaffordable insurance premiums (California Department of Insurance, 2021[188]). The lack of affordable insurance schemes represents a major challenge to wildfire risk reduction in Portugal (OECD, forthcoming[29]) and the United States. In California, in some cases, insurance premiums rose by up to 500% after the 2018 wildfires compared to pre-fire levels (Moss and Burkett, 2020[187]).

Furthermore, underinsurance (i.e. a situation where the maximum pay-out provided by an insurance company is insufficient to cover the full costs induced by a wildfire) also remains a key challenge (GIO, 2022[189]). In Australia, the high levels of underinsurance resulted in significant financial losses for the individuals and communities affected by the extreme wildfires of 2003, 2009 and 2019-20 (Cox, n.d.[190]). For instance, the average claim for properties that were destroyed by the 2009 wildfires in the state of Victoria amounted to approximately half of the actual cost of rebuilding a house (Commonwealth of Australia, 2011[191]).

To address these challenges, some governments have developed legislation that mandates or encourages the uptake of insurance coverage against wildfires. For example, California has recently issued a mandatory one-year moratorium on the non-renewal of insurance in communities affected by wildfire (United Policyholders, 2022[192]). Yet, to date, wildfire insurance is rarely mandated by law (Swiss Re, 2015[19]).

Some governments have stepped in to address insurance viability issues for insurers in an attempt to safeguard existing wildfire insurance markets. Some Australian states have removed existing levies on insurance premiums to help contain their cost (Commonwealth of Australia, 2011[191]; Swiss Re, 2015[19]). France has set up the CatNat public-private insurance scheme to help contain insurance premiums on risks otherwise considered "uninsurable". Funding for the scheme is provided from a state-fixed rate that is added on top of all property and motor vehicle insurance, which are mandatory in France. In addition, the state provides a guarantee to back insurance providers in case of an extreme event (OECD/The World Bank, 2019[193]). Several states in the United States have set up a Fair Access to Insurance Requirements (FAIR) plan to provide insurance coverage to property owners unable to obtain insurance through the private market. In California, the FAIR plan offers broader coverage, as particularly high levels of wildfire risk have pushed a greater number of people out of the private insurance market (The California FAIR Plan, 2022[194]; OECD, forthcoming[53]). The scheme was initiated by the state, but no public money is involved; its operations are controlled and funded by insurance companies (The California FAIR Plan, 2022[194]). In Zambia, the collaboration between insurance institutions and the national bank has made possible the emergence of affordable insurance to protect private enterprises against wildfires and other climate hazards (Inclusivity Solutions, 2020[195]; Swiss Re, 2015[19]).

3.4. Towards an integrated approach to wildfire risk prevention

To enable the development and implementation of risk prevention measures throughout the policy cycle, appropriate institutional and policy arrangements are necessary. Well-designed policy and institutional frameworks enable the integration of wildfire risk prevention across all sectors and levels of government, determining a conducive environment for preventative and adaptive measures. Following particularly extreme wildfires, countries have started acknowledging the importance of adopting a whole-of-government approach in wildfire management, i.e. a collaborative approach that addresses the complex challenge of managing wildfire risk by aligning and co-ordinating the institutional interventions of wildfire management horizontally and vertically across government (McWethy et al., 2019[196]). This has occurred through reforms in both institutional and policy frameworks.

3.4.1. The institutional framework

Wildfire management usually falls under the responsibility of several actors (Table 3.4). In most countries, roles and responsibilities for wildfire management are shared between the national, state, regional and local levels.

Table 3.4. Entities responsible for wildfire management at the national level

Wildfire management role	Responsible entities
Wildfire risk assessment	Government research institutes, meteorological services, academia
Wildfire risk awareness	Ministries of Environment, civil protection agencies, meteorological services
Fuel and ecosystem management	Ministries of Environment, Ministries of Agriculture, and their subordinate agencies
Land-use planning and building regulations	Ministries of Infrastructure, Ministries of Interior, Ministries of Environment, land-use agencies
Emergency preparedness and response	Emergency management: Civil protection agencies, fire services. In some countries, forest services are also responsible for wildfire suppression
	Monitoring and early warning: Government research institutes, meteorological services
Post-fire recovery	Ecological recovery: Ministries of Environment and their relevant agencies
	Socio-economic recovery and reconstruction: Ministries of Infrastructure, Ministry of the Interior

This complex distribution of tasks and responsibilities highlights the importance of having clear roles and straightforward communication and collaboration channels across the different agencies involved in wildfire management. However, recent extreme wildfires have shed light on the faults of institutional frameworks for wildfire management. A number of independent expert committee reports after the 2017 extreme wildfires in Portugal and the 2018 Mati wildfire in Greece highlighted how unclear roles and institutional overlaps and the lack of collaboration among wildfire management agencies contributed to the devastating impacts of these wildfires (OECD, forthcoming[31]; forthcoming[29]). For example, in Greece, until recent reforms, there was no institutional collaboration mechanism between the Forest Service – the main entity responsible for wildfire prevention and the preparation of forest maps, which are key tools in wildfire suppression – and the Fire Service – the main entity responsible for wildfire suppression –, hampering a co-ordinated approach to wildfire management (OECD, forthcoming[31]).

To address the gaps and challenges unveiled by recent extreme wildfires, and with a view to enhancing integrated wildfire management, some countries have developed agencies and mechanisms to promote policy alignment and collaboration, co-ordination, and knowledge exchange across all relevant stakeholders.

Progress has been made in improving horizontal and vertical co-ordination between the public authorities involved in wildfire management thanks to the development of independent national agencies that oversee and co-ordinate wildfire policy across organisations and levels of government. For example, in the aftermath of the extreme 2017 wildfires, Portugal established the Agency for the Integrated Management of Rural Fires, a cross-governmental body under the authority of the Prime Minister that promotes collaboration, capacity and co-ordination by bringing together relevant agencies and stakeholders through cross-governmental committees and lessons learnt processes (Presidency of the Council of Ministers, Portugal, 2021[33]; OECD, forthcoming[29]). Similarly, in the United States, the creation of inter-agency task forces, such as the National Interagency Fire Center, has helped co-ordinate wildfire management efforts across states and federal agencies. In Spain, a similar system was set up to enhance co-ordination across levels of government. Costa Rica's National Commission on Forest Fires also aims to facilitate cross-agency co-operation, bringing together all relevant ministries and agencies. In Greece, a recent institutional reform integrated climate change adaptation and civil protection portfolios under the new Ministry of Climate Crisis and Civil Protection in an effort to enhance synergies across the policy cycle (OECD, forthcoming[31]). In South Africa, the Working on Fire programme has given rise to co-ordination mechanisms involving provincial wildfire protection associations and their local counterparts (UNEP, 2022[197]). In most cases, these mechanisms have proven essential to enhancing dialogue, exchange and co-ordination across public and private stakeholders, eventually reducing wildfire risk (Iseman and Miralles-Wilhelm, 2021[198]).

In parallel, a key step to facilitating cross-government collaboration has involved clarifying roles, responsibilities and cross-agency collaboration mechanisms. Some countries have developed detailed process chains to clarify roles and responsibilities throughout the wildfire management cycle, establishing clear lines of communication, developing standard operating procedures and protocols, and formalising co-operation across actors. For example, in Portugal, the creation of the National Plan for Integrated Wildland Fire Management's process chain established a clear framework for action, with key roles associated with key wildfire management steps (AGIF and IRFMS, 2020[199]; OECD, forthcoming[29]). Similarly, in Greece, the collaboration between the Forest Service and the Fire Service has also improved following a joint ministerial decision and law establishing a clear framework for collaboration (Hellenic Parliament, 2019[200]; OECD, forthcoming[31]; Hellenic Parliament, 2020[201]). Yet, despite emerging good practices, significant challenges remain in implementing an integrated approach to wildfire management, as cross-agency exchange and co-ordination remain low and fragmented in many countries. The growing risk of extreme wildfires only exacerbates these challenges, making it increasingly urgent to address them.

3.4.2. The policy framework

As wildfires cut across sectors and administrative boundaries, effective wildfire risk reduction requires the integration of wildfire risk prevention across the policy framework (Table 3.4). To enable this, some countries have developed national wildfire management strategies and plans that provide an overarching framework for the management of wildfire risk across the national territory, by promoting co-ordination and synergies across policies adopted at different levels of government. For example, in the United States, the National Cohesive Wildland Fire Management Strategy provides guidance for relevant federal agencies on both wildfire prevention and suppression measures, promoting a science-based approach to wildfire management (US Department of the Interior et al., 2001[202]). The strategy emphasises the ecological role of fire, setting out how to avoid overreliance on fire suppression and "fire exclusion" approaches, and facilitates interagency collaboration for integrated wildfire management. Similarly, in 2014, Australia released the National Bushfire Management: Policy Statement for Forests and Rangelands to guide wildfire risk prevention, response and recovery throughout the whole country (Forest Fire Management Group, 2014[203]). Portugal also recently released a National Plan for Integrated Wildland Fire Management, which establishes national policy objectives on wildfire prevention and includes a detailed process chain that clarifies procedures, roles and responsibilities throughout the wildfire management cycle (AGIF, 2020[204]; OECD, forthcoming[29]). In Costa Rica, the National Programme for Integrated Wildfire Management (Programa Nacional de Manejo del Fuego) plays a critical role in the design and implementation of co-ordinated wildfire policies across sectors. Similar efforts are also in place in Lebanon, through its National Strategy for Forest Fire Management, and Morocco, which has a Prevention and Fight against Forest Fires Master Plan (Asmar et al., 2008[205]; Ministry Delegate of the Minister of Energy, Mines, Water and Environment, Morocco, 2014[206]). Despite these emerging examples, and despite growing wildfire risk in the context of climate change in many regions of the world, most countries continue to lack overarching wildfire management strategies. In many countries, such as Italy, wildfire prevention plans only exist at the subnational level (Müller, Vilà-Vilardell and Vacik, 2020[12]).

The degree to which wildfire risk prevention efforts are integrated across all relevant government agencies can be seen in its integration into sectoral policies. Countries have mainstreamed wildfire prevention considerations into sectoral policies and strategies. Recognising the role of the forestry sector in building resilience and adapting to changing wildfire risk through forest management, countries such as Greece, Portugal and the United States have included wildfire prevention measures in forestry strategies. In Portugal, the forest strategy encourages the active management of forests to reduce wildfire risk via fuel management and highlights climate change adaptation as a key priority to tackle extreme wildfire risk (OECD, forthcoming[29]; APA, 2020[63]; Council of Ministers, Portugal, 2015[207]). In Greece, the forest strategy also calls for improved fuel management and the implementation of forest fire prevention plans to strengthen wildfire risk reduction (OECD, forthcoming[31]). A similar forest management approach is already in place in the United States, which has developed forest adaptation strategies for all its federal forests, with a focus on landscape management and capacity (Global Center on Adaptation, 2020[208]). Besides, countries such as Greece and Portugal have also integrated wildfire prevention into their biodiversity strategies, aiming to reduce the negative biodiversity impacts of extreme wildfires and recognising the role of ecosystem health in reducing wildfire risk and their impacts (Ministry of Environment, Energy and Climate Change, Greece, 2014[209]). Furthermore, Portugal's National Programme for Spatial Planning Policy recognises the importance of land-use planning in reducing wildfire risk, identifying key adaptation actions to reduce wildfire risk in rural areas (Government of Portugal, 2021[210]; OECD, forthcoming[29]). Despite these good practices, however, there is still a gap in most countries in the integration of wildfire risk reduction into sectoral strategies.

Finally, as wildfire risk grows in the context of climate change, it is important to integrate wildfire risk reduction into climate policies. Many countries reflect wildfire risk in their national climate policies. Nearly all OECD countries directly refer to wildfires as a key risk in the context of climate change in their National Adaptation Strategy or Plan. For example, France's National Adaptation Plan discusses wildfire risk as part of land-use planning, while Greece's National Climate Adaptation Strategy encourages prevention actions to integrate wildfire risk management into key sectors, such as tourism, forestry and agriculture (OECD, forthcoming[31]; Ministry of Environment, Energy and Climate Change, Greece, 2014[209]; Government of France, 2017[211]; Hellenic Republic, 2018[212]). In Portugal, one line of action of the Climate Change Adaptation Action Programme (P-3AC), i.e. National Adaptation Plan, highlights wildfire prevention as a priority focus and sets out key actions to reduce wildfire risk, including managing fuel accumulation and continuity, strengthening the economic valuation of biomass, and adapting infrastructure networks and support systems to growing wildfire risk (APA, 2019[213]). Portugal and the United States also recognise the challenge posed by extreme wildfires in their Nationally Determined Contribution under the United Nations Framework Convention on Climate Change (WWF, 2021[214]; OECD, forthcoming[29]).

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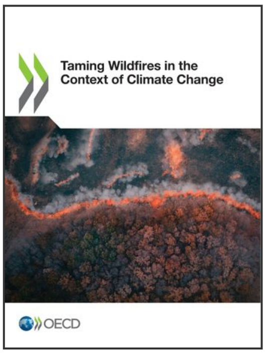
Notes

[1] While the objectives of prescribed fires and cultural fires often overlap to some extent, cultural fires form part of the intangible cultural knowledge of indigenous groups and have a traditional and cultural significance (Office of the Royal Commission into National Natural Disaster Arrangements, 2020[216]).

[2] The International Wildland-Urban Interface Code was developed by the International Code Council to support governments in enhancing wildfire resilience in WUI areas (International Code Council, 2021[215]).



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