



A survival guide for assessing global fire risks to natural and human systems

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ABSTRACT

Compared to tropical cyclones and floods, wildfires have historically been regarded as a secondary peril, which has contributed to the lack of a systemic perspective on global wildfire risk — an understanding increasingly required in disaster risk reduction. This gap is aggravated by the complex and interlinked climatic and anthropogenic drivers of wildfire occurrence, and the diverse and often difficult to interpret landscape of satellite-derived fire datasets, which complicates their use and may lead to inappropriate data choices.

We address these challenges by providing an overview of the systemic pathways of fire impacts, available remote-sensing-derived fire products and modelling efforts. We highlight research gaps and provide recommendations on terminology and data choice. Burned area products are generally used to estimate the extent of burned land and exposed entities, but are characterised by relative high omission errors. Active fire locations constitute a sample taken at the time of satellite overpass, but can provide a proxy for fire intensity. Caution is warranted in intensity metric selection, as these can be biased by latitude, biome and missed measurements. Both data types have been used to derive event-based products. These offer key fire behaviour metrics, such as rate of spread and fire line intensity, yet limited operability results in irregular update cycles. Estimations of population's exposure to fires should also take into account disperse effects from smoke (e.g. $PM_{2.5}$ concentrations $\geq 15 \mu\text{g m}^{-3}$). In parallel, ecological impacts are often associated with burn severity, while natural fire regimes and shifts thereof should be considered.

Contents

1.	Introduction	2
2.	Fire types and their impacts	2
2.1.	Urban fires	3
2.2.	Wild(land) fires	3
2.3.	Managed fires: cultural, prescribed and agricultural burning	4
3.	Characterizing fire drivers and metrics	4
3.1.	Fire weather	4

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3.2.	Ignition, spread and suppression.....	4
3.3.	Fuel	4
4.	Global observational fire data	5
4.1.	Global fire detection via remote sensing: techniques and product features.....	5
4.2.	Global fire products: key satellite missions and core datasets	5
4.2.1.	Thermal anomalies and active fire locations	6
4.2.2.	Surface reflectance and burned area	7
4.2.3.	Derived datasets: event-based fire data, burn severity and emissions	8
5.	Trends in observed fire impacts and underlying changes in global fire regimes, associated extremes and exposure	8
6.	Recorded and modelled fire impacts.....	9
6.1.	Modelled exposure of population and physical assets within the burn perimeter.....	9
6.2.	Modelled population exposure to hazardous smoke	11
6.3.	Modelled ecological exposure and vulnerability	12
7.	Advancing global wildfire risk assessments	12
7.1.	Hazard: global observational and simulated fire data	13
7.2.	Exposure and vulnerability assessment	13
8.	Conclusion and summary of recommendations	14
	CRedit authorship contribution statement	14
	Declaration of competing interest	14
	Acknowledgement.....	14
	Data availability	14
	References.....	15

1. Introduction

Record-breaking wildfires in recent years have underscored the growing global concern about the frequency, intensity, and consequences of wildfire disasters. Notable examples include the deadliest US wildfire in a century, which struck Lahaina, Hawaii in 2023 and resulted in at least 98 fatalities [1]; the 2023 Canadian wildfires, which exposed 50 million people across North American cities, including New York, to hazardous smoke [2]; the January 2025 wildfires in Los Angeles County, the costliest in US history, with estimated economic damages of \$140 billion [3]; and Australia's Black Summer fires during the 2019–2020 season, which led to the loss of nearly 3 billion animals [4]. Together, these events highlight the wide-ranging impacts of wildfires on human and ecological systems; and the urgent need for comprehensive risk assessment approaches.

Although several studies have examined wildfire disasters at global and regional scales — particularly in the US and Australia — they rarely address all components of risk as defined by the Intergovernmental Panel on Climate Change (IPCC). According to the IPCC, climate risk results from the probability of hazardous events and the severity of their impacts, which in turn depend on the interaction between hazards, exposure, and vulnerability; here, hazard refers to a potentially damaging physical event or trend, exposure to the presence of people, assets, or ecosystems in harm's way, and vulnerability to their susceptibility to harm and capacity to cope [5]. Many studies focus on a subset of impact components or have a local focus, leaving both the impacts of wildfires and their probability unquantified on a global scale. This gap reinforces the view that global wildfire risk remains an “understudied area of disaster risk assessment” [6], which is aggravated by the complex and interlinked climatic and anthropogenic drivers of wildfire occurrence and behaviour [6,7]. At the same time, wildfires have historically been regarded as a secondary peril, which has contributed to the absence of a systemic perspective on global wildfire risk in disaster risk reduction (DRR) science — despite the growing consensus in fire science on the need to integrate hazard, exposure, and vulnerability into coherent risk frameworks [8–10]. This gap is further compounded by the diverse and often difficult to interpret landscape of fire data products.

In this review, we present a concise and systematic overview of key factors driving increasing fire risks (Fig. 1): We provide an introduction to the different fire types and their impacts (Section 2); and how fires are characterised based on their drivers and properties (Section 3). A particular focus is placed on globally available fire datasets (Section 4), their limitations, and how they have been used in various impact assessment studies (Section 6), with the aim of improving the accessibility and usability of fire data for scientists and practitioners in DRR. Section 5 discusses trends in observed fire impacts and underlying changes in risk factors. Lastly, we provide an outlook on current challenges and research opportunities in global fire risk assessment (Section 7) and close with a summary of our recommendations (Section 8).

2. Fire types and their impacts

Fires are a natural disturbance process across many ecosystems, necessary to maintain landscapes, but can simultaneously cause significant impacts on natural and human systems. Here, we differentiate between urban fires, wildfires, and fires used as a tool in landscape management (Fig. 1 light orange). We include a discussion of localised and dispersed fire effects (Fig. 1 red), their typical impacts (Fig. 1 blue), and potential pathways for improving resilience [11] through adequate management (Fig. 1 dashed black outer lines).

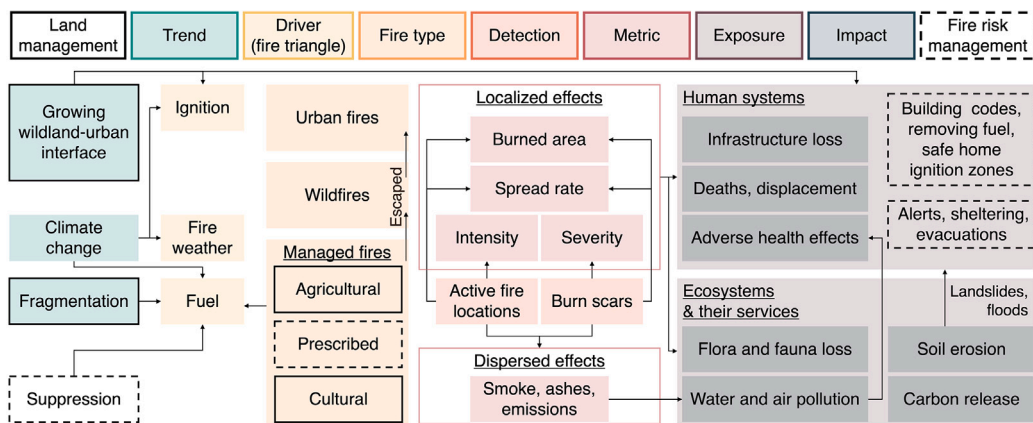


Fig. 1. Schematic illustrating the connections between trends (green, Section 6) influencing different drivers of fires (yellow, Section 3), resulting in different types of fires (light orange, Section 2). These are detected by satellites (dark orange, Section 4). The thereof derived remote sensing products are used to compute both local and dispersed effects and the corresponding metrics (red, Section 4). These can then be utilised to analyse impacts (blue, Section 2) on different exposures (purple, Section 2). Lastly, a range of management options alter either the hazard, exposure or how vulnerable the latter is to fire hazards. We differentiate between fire risk reduction strategies (dashed black outer lines) and broader land management, which might fulfil other targets, while affecting fire occurrence, e.g. the expansion of agricultural lands increasing landscape fragmentation and thereby altering fuel continuity (solid black outer lines).

2.1. Urban fires

The greatest direct impacts on human systems are caused when wildfires spread into human settlements, causing fatalities, displacing people, and destroying infrastructure. Calkin et al. [12] suggest to differentiate between wildfires and ‘urban fires’ initiated by wildfires. These fires affect in particular the *wildland–urban interface* [WUI, 12] — areas where human development encroaches on natural landscapes [12,13]. In the US, most houses lost to fires are either part of, or under a kilometre away from the WUI [14]. This is due to fuel continuity [14], an increased human-induced ignition probability, larger exposures and complicated firefighting [13].

Beyond direct destruction, urban fires cause large (pre)suppression and disaster relief costs [15,16] and release extremely toxic smoke [17]. Adverse health effects such as cancer, cardiovascular, and lung diseases affect fire fighters in particular [18]. Managing wildfires in the WUI requires fuel management, for example, having regular (prescribed) fires [19], landscaping vegetation and focusing on preventing the ignition of homes [20]. Generally, it is recommended to create a safe ‘home ignition zone’ — the house and its immediate surroundings within 100 ft [12]. This includes selecting fire-resistant plants, creating a defensible space by removing vegetation [21] and home hardening [22]. The main fire mechanism leading to house loss is ember attack [23]. Burning material transported by wind can thereby even affect houses before the fire front arrives [19].

2.2. Wild(land) fires

Fires that ignite outside of management practices or escape such controlled settings are classified as wildfires [24]. Wildfires have important ecological functions [8,25], and ecosystems have adapted to the prevailing fire regime. However, changes in these regimes can lead to destructive fires [26] and their spread into formally unaffected areas has important implications for biodiversity [27]. Already in 2003, a study of ten large fire events in the US found that eight out of ten affected forests showed moderate to high deviations from historic forest and fire regime conditions [28].

Ecosystem impacts might also propagate to services that humans depend on. Locally, fire-susceptible vegetation provides wood and regulates both water and climate [8,29]. Potentially heavily affected sectors include timber production and tourism [15,16]. In addition, the removal of vegetation and the increase in soil erosion after fires increase the risk of subsequent landslides and floods [30–32].

Moreover, wildfires might affect places beyond the immediate fire perimeter, here referred to as ‘disperse effects’, including air and water pollution, as well as greenhouse gas emissions. For example, wildfires that occur in forested areas used for drinking water supply could endanger this resource by increasing sediment and nutrient transport [33]. Additionally, fire retardants can promote weed invasion [34] and elevate heavy metal concentrations beyond regulatory toxicity limits for humans and aquatic organisms [35], including fish [36]. On a global scale, wildfires are also an important modulator of carbon sequestration. The contribution of fires to global emissions is estimated to have amounted to 6% of global fossil fuel CO₂ equivalent emissions in 2014 [37]. However, these are generally compensated for by regrowing vegetation in the subsequent years or decades [38]. Net sources remain where ecosystems do not restore or transition to a new stable state with less carbon accumulation. These include degraded peatlands burning and permanent forest loss [37]. Therefore, changes in fire regimes must be considered when planning forests for carbon capture as a mitigation measure of climate change [39,40], in particular in the context of carbon credits [41].

2.3. Managed fires: cultural, prescribed and agricultural burning

For more than 10,000 years, people have used fires to manage land, including polyculture agriculture, territory cleaning, and protection [42]. The benefits are manifold and problems in risk management and conservation arise in places where cultural burnings carried out by indigenous communities have been replaced by fire suppression [42,43]. Similarly, prescribed fires are deliberately ignited and serve several management purposes. Among others, they reduce accumulated fuels and thereby help prevent extreme wildfires (see Section 3.3; [24,44]), and they improve pasture quality [45], with ungulates often preferentially grazing recently burned patches [46].

Fires are also used in agriculture to clear land [slash and burn — deforestation; 47] and to dispose of crop residues [48]. The main impacts of agricultural fires are air pollution, soil degradation [49], and forest loss [47].

Smoke from fires contributes significantly to air pollutant emissions with important detrimental effects on human health (see Section 6.2 on fire smoke and health impacts). In parts of the world, where agricultural burning is a common practice, such as in South Asian countries [48], quantifying health impacts might encourage the adaptation of alternative uses of crop residuals. These include biogas power plants [50,51] and on-site use of residuals, e.g., by composting, in situ management or the creation of biochar [50]. Similarly, it is important to take into account trade-offs of prescribed burns for public health. Considering dispersal in planning can reduce total smoke emissions and ideally allows for less total smoke exposure [52].

3. Characterizing fire drivers and metrics

The controls of fires follow similar patterns across spatial and temporal scales [53]. These are described by the ‘fire triangle’, which has many variations but usually contains the components fire weather/climate, ignition and fuel/vegetation (see Fig. 1 yellow; [53–55]).

Unlike other natural hazards, such as hurricanes, which have a straightforward event definition, the delineation of single fire events is more ambiguous and requires setting spatial and temporal boundaries. Efforts to describe the multidimensional properties of fires on a landscape scale have delineated global fire regimes also referred to as ‘pyromes’ [56,57]. These share properties such as fire size, extent of regionally burned area, frequency, season and intensity (Fig. 1 red, Table 1; [56,57]). The analysis of pyromes allows to improve our understanding of different drivers [57], which are altered both by climate change and land use change [26].

3.1. Fire weather

Weather is a significant driver of wildfire activity due to its influence on fuel moisture and fire spread. Variations in weather and climate, such as temperature, precipitation, humidity, and wind, can modulate vegetation growth and fuel aridity, affecting the flammability of the landscape [58]. Wet years can lead to above average fuel build-up [59,60], while hot and dry conditions make the environment more susceptible to ignition and rapid fire spread [61]. Wind is a key driver of fire behaviour, affecting spread, intensity, and the likelihood of ignition [62]. For example, wind can carry burning embers, igniting spot fires far from the main fire source [63]. Weather variables are routinely combined as fire weather indices, which are used in wildfire management to assess the potential for high wildfire activity. The most common fire weather index system (consistent of a set of indices) is the Canadian Fire Weather Index FWI [64].

3.2. Ignition, spread and suppression

Fire ignition, spread and extinction has both natural and human controls. Lightning is the main source of natural ignitions, and potential changes in lightning patterns under climate change could affect the probability of wildfires [65]. Moreover, humans are both a source of ignition and suppression [24,55]. The ignition source influences the intensity and severity of fires, with human-made fires in California coinciding with more favourable fire weather and therefore spreading faster and burning at higher intensities [66]. The spread of fires is generally driven by wind (see Section 3.1); fuel availability and type (see Section 3.3); as well as by topography, which can, on the one hand, create fire barriers and, on the other preheat and dry up-slope fuels, causing fires to spread faster uphill than downhill [67].

3.3. Fuel

The amount, type, moisture and continuity of fuel directly influence the behaviour of wildfires. Fine fuels like grasses and leaves dry easily, and can rapidly carry and spread fire in arid and semi-arid ecosystems [68]. Because spatially continuous fuels sustain fire spread, increasing landscape fragmentation can reduce burning [54,69]. Conversely, land management practices focused on fire suppression have led to fuel accumulation in many parts of the world, contributing to more intense and severe fires [1,24].

Wildfires differ from other hydrometeorological hazards as they show pronounced spatial and temporal dependence between events: the frequency of the fire depends on the fuel consumed and is expected to be negatively correlated with intensity (Table 1; [56]). For example, grasslands usually burn more frequently and at lower intensities than forests [68]. The ‘intermediate fire occurrence-intensity’ hypothesis posits that fire frequency and intensity follow a humped relationship where fire occurrence increases with intensity up to a point, beyond which fuel limitations prevent further increases [70].

Table 1
Definitions of properties used to characterise wildfires.

Term	Description
Occurrence	Point, binary observation
Size/perimeter	The size of individual fires (as a polygon)
Extent	Total burned area over a region and year/season
Fire behaviour	Is the way fire ignites, spreads, and reacts to its environment. It includes factors like flame length, fire line length, speed (spread rate) and intensity.
Fire intensity	Is commonly described by Byram's fire intensity, which measures the energy rate released per metre of fire line and time unit [unit kW/m; 71–73]. Measurements have been performed both in experimental fires and using ground-sampling methods [72] and estimated using remote sensing data, mainly fire radiative power (FRP). See Section 4.2.1 on the detection of FRP and Table 6 on derived intensity metrics used in impact assessments.
Fire or burn severity	Describes the magnitude of change in organic matter both aboveground and belowground [71]. It is relevant to the landscape's susceptibility to post-fire hazards such as landslides, floods and changes in water quality [74].
Fire return intervals	Are the inverse of fire frequencies. When the fire return interval exceeds the observational time period it is commonly estimated by space–time replacement across a larger region governed by the same fire regime: It is computed by dividing the mean fraction of burned area by the total area. This approach is most reliable for return intervals below 50 years [56].

4. Global observational fire data

While some countries maintain detailed fire records [75], the most consistent global fire time series come from satellite observations. However, differences between remote sensing products can be difficult to interpret, making it challenging for DRR scientists to select appropriate datasets. To support informed use, we first describe global fire detection via remote sensing (Section 4.1; Fig. 1 dark orange), followed by a summary of global datasets (Section 4.2) and the metrics they entail (Fig. 1 red).

4.1. Global fire detection via remote sensing: techniques and product features

Satellite-derived fire products typically fall into two categories (Table 2): (1) active fire detections, which use thermal measurements to identify the radiative energy emitted by flaming fire fronts and smoldering zones; and (2) burned area estimates, which map post-fire effects based on changes in surface reflectance and spectral characteristics resulting from vegetation charring or loss, ash deposition, and exposed soil. Active fires only detect what is burning at the time of satellite overpass (when not occluded), while burned area can be detected for longer time. However, the spectral signal of an active fire is easier to detect than that of a burned area. Consequently, errors in active fires are predominantly due to observation limitations, while burned area errors are caused by spectral confusion. Review papers provide in-depth summaries of these products' development and future needs; see Wooster et al. [76] for active fire products and Mouillot et al. [77] for burned area products. Both product types are used to estimate fire emissions, but through different approaches. Burned area data are typically fed into biogeochemical models, whereas active fire detections enable direct emission estimates by applying parametric relationships to observed fire intensity (see Section 4.2.3; [78]).

To assess the quality of these products, high-resolution satellite imagery and aerial data are commonly used to evaluate commission (false positive) and omission (false negative) errors — e.g. 30-m ASTER for active fire locations [79] and Landsat for burned area [80].

4.2. Global fire products: key satellite missions and core datasets

Geostationary satellites remain fixed over specific regions of the Earth, providing high temporal resolution and frequent revisits [e.g., 81]. In contrast, polar-orbiting satellites circle the Earth, offering global coverage; wherefore, we focus here on these missions and their derived fire data products.

We provide information on their operational availability as well as repositories to access the data. Operational systems and near real-time availability play an important role in coordinating disaster mitigation efforts such as suppression and evacuations [10]. Moreover, operational and regularly updated data products are important for updating risk estimates, e.g. to price insurance [82].

The embedding in long standing projects can promote such regular updates. Examples of such projects are NASA's *Fire Information for Resource Management System* (FIRMS¹), the *Global Fire Emissions Database* (GFED²), Copernicus' *Global Wildfire Information Systems*

¹ https://firms.modaps.eosdis.nasa.gov/active_fire/, accessed 2025-08-15.

² <https://www.globalfiredata.org/index.html>, accessed 2025-08-15.

Table 2

Comparison of global remote sensing fire products.

	Active fire locations	Burned area
Detection	Thermal anomalies	Surface reflectance (burn scars)
Intensity	Brightness temperature [K] Fire radiative power FRP [MW]	Binary [burn/no burn]
Timing	Exact timing	Estimated date
Update	Near real time	Lag of 2–3 months
Emissions	Directly using parametric relationships with FRP	Indirectly using biogeochemical models
Strengths	Requires smaller fire size for detection; near real-time availability	Possible to detect days/weeks/months after the fire occurred
Limitations	Instantaneous detection of activity in overpass moment (biased temporal sample); omission errors due to smoke or clouds; includes other thermal anomalies (e.g. gas flaring)	Requires fires to cover a considerable fraction of the cell (omits small fires)
Applications	Quantifying intensity and contribution of small fires; refine time of burning; monitor events	Derive areas affected by moderate-large fires

Table 3

Overview of selected orbiting satellite missions operated by NASA and NOAA and providing data through the Fire Information for Resource Management System FIRMS.

Mission	Satellites	Data start date
MODIS	Terra	Nov 2000
	Aqua	Jul 2002
VIIRS	S-NPP	Jan 2012
	NOAA-20 (JPSS-1)	Apr 2018
	NOAA-21 (JPSS-2)	Jan 2024
	Planned (2 satellites)	By 2031

(GWIS³) and the *Fire Disturbance project* (Fire_cci⁴), conducted under the European Space Agency's (ESA) Climate Change Initiative (CCI).

FIRMS provides data from the *Moderate Resolution Imaging Spectroradiometer* (MODIS, Table 3) and its successor, the *Visible Infrared Imaging Radiometer Suite* (VIIRS, Table 3). The satellites carrying MODIS instruments are already experiencing orbital drift and are expected to be decommissioned between late 2025 and mid-2026. Their successor, VIIRS (five satellites planned), will ensure continuity of global fire observations.

In this review, we focus on MODIS- and VIIRS-derived data products (Table 4), as they are operational and openly available. Ongoing efforts aim to develop active fire and burned-area detection products from other satellite missions — such as AVHRR [83], Sentinel-2 and -3 [84], and Landsat [85] — but these systems are not yet operational at the global scale. Data alternatives also include commercial data provided by private companies (e.g., OroraTech⁵).

4.2.1. Thermal anomalies and active fire locations

Active fire locations (also referred to as hotspots) register points of thermal anomalies and their brightness temperature in Kelvin. Thereby, they record the exact time of burning and an estimate of the fire's heat. Additionally, FIRMS active fire products provide the *fire radiative power* (FRP), which estimates the instantaneous radiant energy released by a fire. It can be derived from the brightness temperature and other factors such as the background radiance, the pixel size, the atmospheric transmittance and several constants [Equation 16 in reference 79]. The total energy released by a fire has been estimated by using several satellite overpasses and integrating FRP over time, yielding the *fire radiative energy* [FRE, 86]. Combining data from a geostationary and orbiting satellite can provide land cover specific correction factors of FRE, while accounting for additional factors such as the diurnal cycle of fires [86]. An important application of FRE is in estimating emissions, as FRE has been shown to have a linear relationship with the total consumed fuel and related emissions ([87,88], see Section 4.2.3 for details on emission estimates;).

The primary advantage of active fire products is their higher sensitivity to small fires [89,90] and the exact capture of the time of burning. Their higher sensitivity makes them particularly suitable to improve estimates of the contribution of such small fires (e.g. agricultural burnings) to burned area and emissions [89,90]. Moreover, they are used to refine burned area products with regard to the timing of fires [91].

³ <https://gwis.jrc.ec.europa.eu/applications/data-and-services>, accessed 2025-08-15.

⁴ <https://climate.esa.int/en/projects/fire/>, accessed 2025-08-15.

⁵ <https://ororatech.com>, accessed 2025-08-15.

Table 4

Global MODIS and VIIRS derived fire products: their coverage and resolution, as well as a description of their operational availability and data repositories.

	Name	Temporal coverage	Temporal resolution	Spatial resolution	Operational availability	Updates; repository
Active fire locations	MODIS V061	Since 11/2001	12 h	1 km	Will be decommissioned	Daily ¹
	VIIRS V002	Since 01/2012	12 h	375 m/750 m	Planned operationally	Daily ¹
Burned area	MCD64A1	Since 11/2001	Daily	500 m	Will be decommissioned	2–3 months ⁶
	Fire_cci51	2001–2022	Monthly	250 m/0.25°	Part of Fire_cci project	[92]
	VNP64A1	03/2012–07/2025	Monthly	500 m	Not yet operational	⁷
Burned area (crop land, aggregated)	GloCAB	07/2002–12/2020	Monthly	0.25°	Part of GFED ²	[93]
Burned area (aggregated)	GFED5	1997–2001	Monthly	1°	Part of GFED ²	[94]
		2001–2020	Monthly	0.25°	Part of GFED ²	[94]
Fire events	Global Fire Atlas	2002–2024	Events	Perimeter	If funding permits [95]	[96]
	GlobFire	2002–2023	Events	Perimeter	Operated by GWIS	³
Burned area NRT (perimeter)	Derived from thermal anomalies	For current season	Events	Perimeter	Operated by GWIS	Daily ³
Emissions	GFED4s	1997–2023	Monthly	0.25°	Part of GFED ²	²
	GFED 500 m	2002–2022	Monthly	500 m/0.25°	Part of GFED ²	[97]
	GFAS	Since 2003	Daily	0.1°	Operated by GWIS	Daily ³
	Smoke plume $PM_{2.5}$	2003–2023	Daily	0.2°	Used in Lancet Countdown health report [98]	[99]

Limitations of active fire products stem from their momentary depiction of active hotspots, which can lead to biases if not properly treated. These include latitudinal differences in pixel size, scan angle, and overpass frequency, with pixels closer to the equator covering larger areas and being observed less frequently at less favourable viewing angles. These biases are further accentuated by variations in fire behaviour (e.g., spread rate and persistence of burning, i.e. how long the fire smolders in a specific spot), which influence how fires evolve between successive satellite observations [89]. Furthermore, sub-pixel variability in the length of the active fire front strongly influences the retrieved FRP, since the total emitted energy depends not only on the front temperature but also on its spatial extent within the pixel. Moreover, as these are point detections, it is ultimately unknown how much of the pixel has burned. Consequently, active fire locations represent a relative measure of fire activity [89]. Differences in burned-area estimates derived directly from active fire detections also depend on the affected biome. Missed detections are particularly common in fast-burning fuels, since fires can spread substantially between satellite overpasses, and most overpasses occur in the early morning or early afternoon — outside the diurnal peak of fire activity — resulting in higher detection accuracies in slower-burning forests than in savannas, grasslands, and croplands [100]. Lastly, active fire detections can be obscured by clouds and smoke [89], and may also include other thermal anomalies unrelated to wildfires. These include offshore gas flaring [79], volcanoes, industrial activities [101], as well as sun glint from lakes [79], solar panels, and other highly reflective surfaces. Studies using thermal anomalies to assess fires usually try to remove these non-vegetation fires [89,102].

MODIS and VIIRS use heritage versions of the same active fire detection algorithm, and the resulting data are distributed via FIRMS at 24-hour, 48-hour, and 7-day temporal resolutions (Table 4). However, transitioning from MODIS to VIIRS requires harmonisation of the datasets, partly due to their differing spatial resolutions. The higher spatial resolution of VIIRS (375 m) compared to MODIS (1 km) enables a substantially improved delineation of fire perimeters [103].

4.2.2. Surface reflectance and burned area

In contrast to active fire detections, burned-area products require that a substantial fraction of a pixel be burned in order to register a detection. However, because burned-area mapping can be performed days to months after a fire, these products provide more comprehensive coverage of fast-moving events [89].

Burned area is derived from reflectance changes between healthy and charred vegetation, typically using a set of burn-sensitive vegetation indexes such as the *difference in Normalised Burn Ratio* (dNBR). Active fire detections are also often incorporated, for example, to estimate the burn date of each pixel.

Estimates of annual burned area on a global scale have increased with improved algorithms. The latest MODIS burned area product (MCD64A1,⁶ Table 4) has seen an increase of annually burned area by 26% (from 337 to 423 Mha globally), mainly due to an improved detection of small fires and a large increase in the extent of mapped areas. In Boreal North America, excluding small lakes resulted in a net reduction of burned areas by 6% [91]. The Fire_cci project uses the MODIS surface reflectance and active fire locations to derive a high-resolution burned area product at approximately 250 m, with an average annual burned area

⁶ Available at <https://doi.org/10.5067/MODIS/MCD64A1.061>, accessed 2025-08-15.

of 381 Mha (Table 4; [104]). The second version of a VIIRS burned area product⁷ (currently only using S-NPP data, see Table 3) builds upon the earlier provisional release (Table 4; [105]).

As discussed in Section 2, differentiating fire types can be relevant for some applications. Efforts to capture agricultural fires have resulted in a global monthly cropland burned area database named GloCAB [106]. GloCAB combines MODIS active fire locations [79] with burned area conversion factors on field-level [106]. GloCAB as well as GFED provide fractional burned area estimates on spatially coarser, aggregated scales (Table 4). The latest (fifth) version of GFED (GFED5) combines MODIS burned area with GloCAB [107] and a statistical scaling leveraging MODIS active fire locations inside and outside of MODIS burned area [94]. GFED5 has seen nearly a doubling in global burned area estimates (774 Mha) compared to MODIS burned area estimates alone. These are mostly due to formally underestimated cropland burnings and prescribed fires [108].

4.2.3. Derived datasets: event-based fire data, burn severity and emissions

Event-based fire products rely on tracking and clustering algorithms. In principle, they can be derived from active fire detections [74,109], burned area datasets [95,110,111], or a combination of both. Burned-area-based approaches are currently the most operational on a global scale, while others remain under development. Event-based products can contain information on ignitions, fire size, duration and spread [95]. Examples include the *Global Fire Atlas*⁸ [95] and the *Global Wildfire Dataset GlobFire* [111], which are both based on the MODIS burned area product (Table 4). The global database of fire patch functional traits FRY combines MODIS burned area with burned area estimates of the *Medium Resolution Imaging Spectrometer* [MERIS, 112]. GlobFire forms part of GWIS, which also provides daily updated burned area perimeter³ based on a combination of MODIS and VIIRS active fire locations.

Burn severity mapping is not yet operational globally; however, research datasets such as MOSEV [113] and the *Global Forest Burn Severity* (GFBS) product [114] demonstrate recent advances towards global coverage.

Estimates on global fire emissions and air pollution are derived following the two approaches discussed in Table 2. GFED provides emissions estimates based on biogeochemical models both on a coarser resolution with a more complex model (Table 4; [37]) and on a higher spatial resolution with a simplified approach (Table 4; [78]). GFED combustion rates have also been used to derive conversion factors linking FRP to emissions. These are provided by The *Global Fire Assimilation System* [GFAS, 101] and are updated daily on the ECMWF datastore. However, regional emission estimates can be substantially higher. For instance, FRP-based measurements from a geostationary satellite in southern Africa indicate average total particulate matter emissions 45% higher than those in the GFASv1.2 inventory [115]. Similarly, large uncertainties and the lack of robust datasets dominate estimates of agricultural fire emissions in South Asia [48], a region where particle densities are prone to underestimation [116]. In addition to GFED and GFAS, several other global fire emission inventories are available, including FEER [117], FINN [118] and QFED; see [119] for a comprehensive comparison.

Combining emission estimates with an injection height and smoke plume model allows the quantification of smoke dispersion and affected populations both near and far from the original fires (see Section 6.2; [98,120]). Alternatively, atmospheric composition can be measured directly using products such as MODIS *aerosol optical depth* [AOD, 121] or TROPOMI [122].

5. Trends in observed fire impacts and underlying changes in global fire regimes, associated extremes and exposure

Impacts records of both human and natural systems have increased in recent decades, in particular in the Global North. Insured fire losses have risen sharply: 70% of all claims between 1980 and 2020 were issued in the time period 2016–2020,⁹ and annual US losses in 2017–2018 saw a fourfold increase compared to historic averages over 1985–2018 [123], despite raising suppression expenditures [123–125]. Rising impacts are commonly attributed to a combination of a changing climate, fuel accumulation, and the expansion of the WUI (Fig. 1 green; [1,126]). However, regionally, trends in these risk factors vary strongly.

Globally, total burned area has decreased over the past two decades [108], largely due to agricultural expansion and the resulting fragmentation of savannas, particularly in Africa [127]. At the same time, increasingly extreme fire weather has led to rising burned area in forests, including an estimated 50% increase in extratropical forests [69]. Already today, 16% of global burned area can be attributed to climate change [128] and fire weather is projected to intensify considerably under further emissions [69]. This also includes intensifying feedbacks driven by hydroclimatic volatility (see Section 3.3; [60]). Additionally, the severity of fires is intensified by accumulated fuel as a bi-product of fire suppression [24], changes in vegetation due to encroachment, the emergence of invasive species or ecosystem transitions.

The characterisation of fire extremes beyond burned area is generally ambiguous, as it can be described in terms of intensity, burn severity, spread, synchronicity, size, and impacts [129]. The term ‘megafire’ mostly refers to the size of fires, e.g. exceeding 10 000 ha [130]. Globally, extremes in sum of FRP have increased [102], although it is debated whether this is to be interpreted as an increase in intensity or instead in fire size and simultaneity [52,131]. In the US, the speed of fires has doubled in the time period 2001–2020, complicating the management of active fires [132].

Simultaneously to shifts in fire regimes, human exposure to fires has increased in several regions of the world, driven by an increase in population density, in particular in Africa [133], and an expansion of the WUI, in particular in the US: Since the 1990s,

⁷ Available at <https://doi.org/10.5067/VIIRS/VNP64A1.002>, accessed 2025-08-15.

⁸ Updated version available at: <https://doi.org/10.5281/zenodo.11400062>, accessed 2025-08-15.

⁹ <https://www.swissre.com/risk-knowledge/mitigating-climate-risk/yes-more-wildfires.html>, accessed 2025-08-15.

Table 5

Overview of references on global exposure data, vulnerability and impact records related to fires.

	Population	Physical assets	Forests
Exposure	GPWv4 [135]	LitPop [136]	MODIS land cover [137]
Vulnerability	Smoke [120] $PM_{2.5} \geq 15 \mu\text{g m}^{-3}$	Based on LitPop [138]	–
Impact records	IDMC [139], EM-DAT [140]	EM-DAT [140]	[47,141]

the number of houses built in fire-prone landscapes has risen [13], contributing significantly to socio-economic fire impacts. Annual structure losses in the Western US are well explained by burned area resulting from human-related ignitions and on a decadal scale, the number of structures in flammable vegetation at the state level is a good predictor of loss of structures [134]. This development has led to urban fires being described as “national crisis in the US” [12].

6. Recorded and modelled fire impacts

In this section, we summarise research efforts on quantifying the impact components hazard, exposure and vulnerability. Exposures susceptible to wildfires include people, physical assets and ecosystems such as forests (see Section 2).

Globally available exposure datasets include the Gridded Population of the World (GPW), which is a rasterised census data product [135]. Similarly, LitPop disaggregates national-scale macroeconomic indicators as a function of population density and night light intensity [136]. Lastly, satellite derived annual land cover datasets are available e.g. based on MODIS [137], which can be used to study e.g. impacts on forests. Table 5 entails global remote-sensing-derived datasets to represent these exposures, their vulnerability to fires and historic impact records.

Global, open-source disaster databases are known to be incomplete and biased towards the Global North. Fig. 2 shows socio-economic impact records extracted from the *Emergency Events Database* [EM-DAT, 140] and the *Internal Displacement Monitoring Center* [IDMC, 139]. Many high-impact fire events — particularly those with significant absolute economic damage (Fig. 2a,b) — have been recorded in North America and to a lesser degree in Europe. EM-DAT records of affected people are dominated by the Brazilian Amazon rain forest fires in 2019, with a total of 10 million affected people (Fig. 2c,d), leading to 3400 additional deaths from fire smoke [142]. This event emphasises the potential dispersed impacts of wildfires, which affected people far beyond the immediate burn perimeter. While socio-economic impact records are typically reported through bottom-up processes, global estimates of forest loss rely largely on remote-sensing observations [47,141].

Quantitative knowledge of vulnerabilities is limited on a global scale. These are commonly either based on empirical knowledge (e.g. recommended concentration limits of smoke) or derived by linking hazard intensity to historic impact records [143]. While in the following we focus on global studies linking remote-sensing-derived fire intensities (burned area, intensity, spread, emissions) to impacts, we also include some analyses on impacts in the US and Australia, as these can draw from more accurate impact records.

Sophisticated fire models can estimate intensity and related impacts at local scales. For example, a study in Oregon assesses vulnerabilities of exposures ranging from energy infrastructure to municipal watersheds using model-derived fire intensity categories that approximate flame length from both fuel consumption and rate of spread [144].

However, the application of such models to larger regions remains challenging. A key limitation in global assessments of localised wildfire impacts is the lack of consensus on how to best quantify fire extremes from remote-sensing data [130,131,145] and consequently how to define the hazard intensity relevant to impacts. Fire intensity has been derived from active fire measurements in a few ways (Table 6). When using FRP one should address the wider range of biases including missed measurements, varying overpass frequencies and view angles, the diurnal cycle of fires, land-cover and biome differences (see Section 4.2.1). Because FRP reflects both smoldering and flaming phases, individual measurements are less informative of the maximal energy released by a fire. When using the sum of FRP, we highlight the need to account for biome differences, overpass frequency and missed measurements. For example, this metric penalises fast-moving fires, which are likely to be linked to increased impacts [66,132]. We suggest using the 95th percentile of FRP as a simple approximation of peak FRP i.e. fire line intensity [56,146]. In addition, uncertainties can be reduced by excluding measurements with a large scan angle ($>50^\circ$), low confidence ($<30\%$) as well as normalising FRP values by pixel size [146]. Lastly, intensity approximations can be combined with burned area or event-based products, to account for the spatial extent of the affected area. For example, the report *State of Wildfires 2024–25* analyses fire intensity by computing peak FRP for events in the Global Fire Atlas [3].

Alternatively to FRP-derived fire intensities, fire spread has been shown to drive impacts: Fast spreading fires were associated with 78% of lost structures in the US in the years 2001–2020 [132] and with increased tree mortality in California [66]. This is partly due to higher associated intensities [66], but also to fast spreading and synchronous fires overstraining suppression efforts [132].

6.1. Modelled exposure of population and physical assets within the burn perimeter

Burned area products are commonly used to estimate areas exposed to wildfires [3,133,149], and can be combined with land use information to differentiate between agricultural fires and wildfires [133]. The report *State of Wildfires 2024–25* includes estimates of exposed population and physical assets based on burned area and a static representation of people and assets (Fig. 3; [3,150]). This approach notably underscores the concentration of exposed assets in Asia (Fig. 3a,b) and of exposed populations in Africa (Fig. 3c,d). Population estimates indicate rather a decrease in exposure, dominated by a decrease on the African continent (Fig. 3d). This

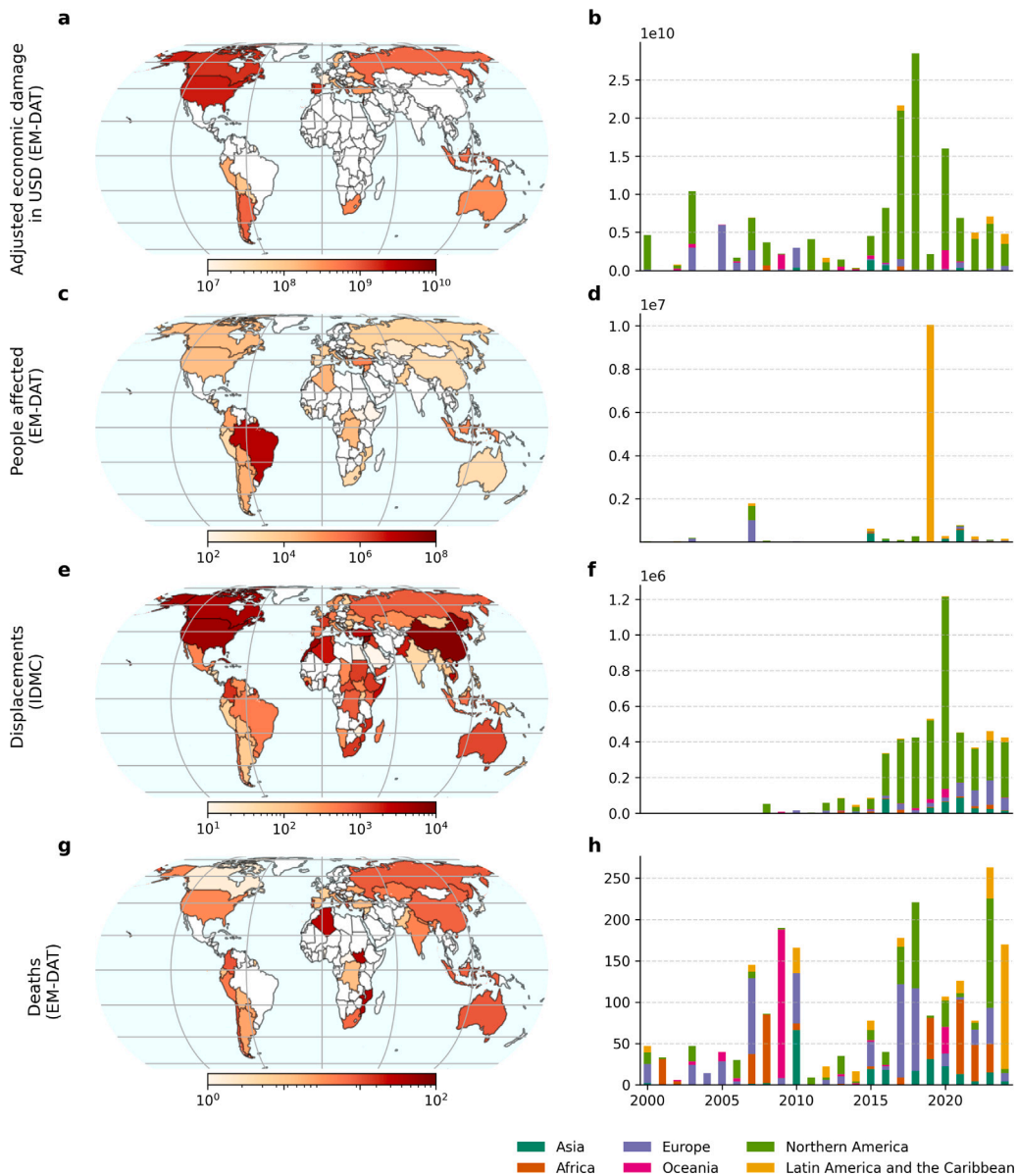


Fig. 2. Global socio-economic impact records: (a,b) Adjusted economic damages, (c,d) Affected population and (g, h) Direct deaths recorded by the Emergency Events Database EM-DAT in the years 2000–2024 [140]. (e,f) Displaced population recorded by the Internal Displacement Monitoring Center IDMC in the years 2008–2024 [139]. (a,c,e,g) Average impact per calendar year per administrative region. (b,d,f,h) Time series of annual sum per continent.

is likely driven by the static exposure, as a recent study including dynamic exposure shows divergent trends between population exposure trends in Africa when comparing static and time-varying exposure [133]. Similar trends are projected for the future by using burned area projections generated by the coupled vegetation-fire model LPJ-GUESS-SIMFIRE and overlaying them with population projections: The authors find that a future increase in exposed population is mainly a consequence of population growth in fire-prone regions and not of climate change [149].

However, presence within the fire perimeter represents rather an upper limit estimate of potentially affected entities [3]. Using impact records, the mean damage ratio for assets is estimated to be 29% [based on 105 EM-DAT events; 3] and 3% for exposed population [based on 521 IDMC events; 3].

Table 6

Active fire location derived intensity metrics used in impact assessments, mainly deploying fire radiative power (FRP) estimates.

Metric	Description
Individual MODIS FRP measurements	Fire categories analogous to intensity rankings of other natural hazards, such as the Saffir–Simpson scale for hurricanes or the Richter scale for earthquakes. “Categories are arbitrarily proposed as a reasonable scale for describing the strength of fires.” [147]
MODIS maximum brightness temperature on a 1, 4, 10 km grid	The global vulnerability of physical assets is derived by overlaying spatially explicit hazard and exposure data and calibrating impact functions with EM-DAT impacts records [138]. Caution is warranted regarding biases related to the transformation of measured temperature to FRP (e.g. background radiance) and outliers affecting maxima.
Event-based VIIRS mean fire line FRP	The mean FRP is computed along the fire line. Fire front intensities are shown to be correlated with spread rates, severity and tree mortality [66]. The approach requires an event-based dataset, currently unavailable operationally, in particular on a global scale.
Event-based VIIRS mean, max, and area normalised total FRP	Stratified by vegetation type, fire behaviour metrics such as FRP and spread rate are positively correlated with burn severity. The approach allows to estimate burn severity directly from active fire locations [74].
MODIS daily sum in FRP on a 10 km grid	Extremes (≥ 99.99 th percentile) in daily sum of FRP and their co-occurrence with reported disasters [59,102,148] and exposed population [133]. The sum of FRP is a convolution of intensity, size and simultaneity [131].

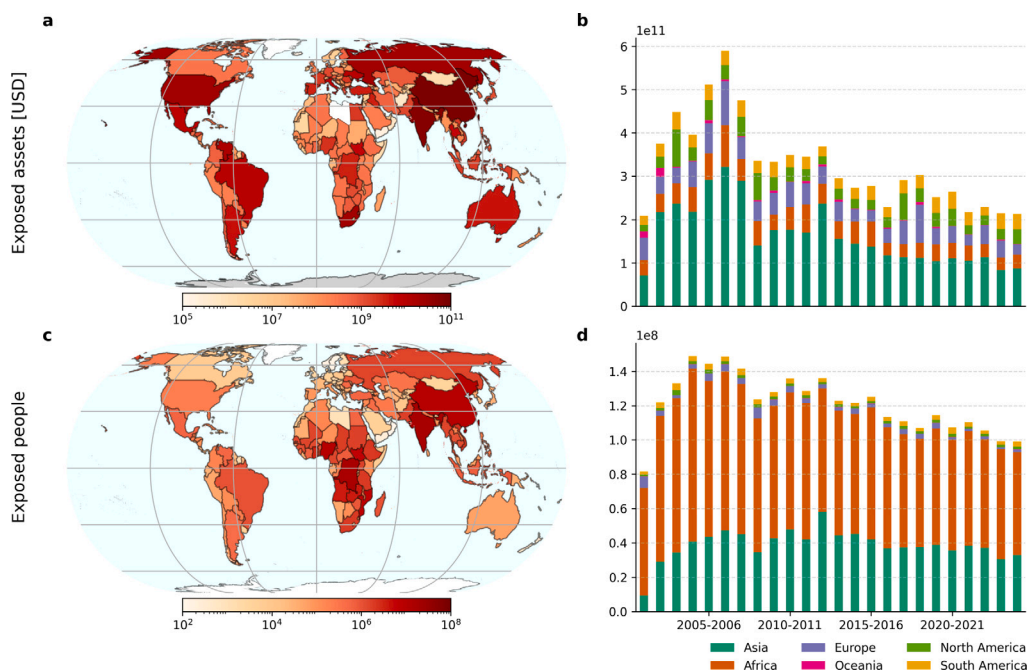


Fig. 3. Global socio-economic exposure estimates: (a,b) Physical assets and (c,d) Population exposed to burned area, computed for the report *State of Wildfires 2024–25* [150]. (a,c) Average impact per wildfire season (Mar–Feb) per administrative region. (b,d) Time series of seasonal sum per continent.

6.2. Modelled population exposure to hazardous smoke

Smoke has detrimental effects on human health. These include impacts on cognitive performance [151], impeded health at birth when mothers are exposed to smoke during late-pregnancy [152], increased child hospital visits [153] and excess-mortality [154, 155].

Fine particulate matter with a diameter of $2.5\mu\text{m}$ or smaller is often used to characterise toxic air quality. The World Health Organisation (WHO) concentration threshold amounts to $PM_{2.5} \geq 15\mu\text{g m}^{-3}$ [120] and the threshold $PM_{2.5} \geq 30\mu\text{g m}^{-3}$ has been used to analyse increased mortality due to smoke [154]. In order to quantify effects both on close and distant populations, FRP-derived emissions can be combined with a smoke plume model [e.g. reference 99]. The 2023 report of the Lancet Countdown on health and climate change [98] quantifies the number of people exposed to dangerous amounts of fine particles ($PM_{2.5} \geq 30\mu\text{g m}^{-3}$) in the years 2003–2023 globally. The exposure to wildfire smoke decreased in 56 countries and increased in 7 countries compared to the 2003–2007 reference, while the estimated global mean concentration remained stable during 2003–2022. The most significant increases were detected in eastern Siberia, western US, Canada, and India [98]. Similarly, using the WHO threshold, a study finds that most leading countries for their five exposure metrics were low- and middle-income countries, but also included the US, Japan and Chile [years 2000–2019; 120].

6.3. Modelled ecological exposure and vulnerability

In particular in the analysis of ecosystem impacts, it is important to keep in mind that ecosystems are also dependent on fires and their mere exposure might have positive effects [27]. Although tree mortality has been shown to be locally related to fire intensity and burn severity [66], we are unaware of global quantifications of forest vulnerability.

Exposure of forests and grasslands has however been included in a *Global Atlas of Natural Disaster Risk* [156]: Global forest wildfire risk is quantified as fraction of burned area in comparison to the total forested area. On a national level this leads to Russia being historically the most exposed country [157]. Importantly, this does not translate into actually lost forest, but would require assessing related vulnerabilities, e.g. by using forest loss data. Fire-related and non-fire-related forest loss can then be separated either by combining forest-loss maps with fire detections [47] or by using a classification model trained on visually interpreted samples [141]. Estimates of the share of global forest loss attributable to fire vary across approaches. The classifier-based analysis by Tyukavina et al. [141] finds that 26%–29% of global forest loss between 2001 and 2019 was due to fire. In contrast, van Wees et al. [47], using burned area and active fire detections to attribute loss, report that approximately 38% of global forest loss is fire-related. They also note that omission errors associated with small fires tend to be offset by commission errors from coarse spatial resolution when aggregated to regional or continental scales. Trend estimates likewise differ between studies. Van Wees et al. report a declining trend in fire-driven forest loss in the Amazon from 2003–2018, largely due to an earlier peak in deforestation-related fires. In contrast, Tyukavina et al. identify an increasing trend over 2001–2019 in the same region.

In grassland ecosystems, the primary assets exposed to fire are those associated with the livestock industry. Consequently, the net primary production of pastures is taken as the value at stake, which leads to Brazil and the United States exhibiting the highest estimated grassland fire risk [158]. In these systems, it is reasonable to assume that burned grassland is temporarily lost for pasture production, although prescribed fires are also widely used to improve forage quality [45].

Generally, we highlight active fire derived event-based datasets as a promising resource for quantifying burn severity [e.g., 66,74] as a central metric for ecological impacts. Depending on the impacts studied, different intensity proxies may be appropriate to explain these. For example, flora and fauna in Australia were found to be most affected after the megafires of 2019/2020 where they had been exposed to frequent and recent past fires [159].

7. Advancing global wildfire risk assessments

Understanding past impacts in combination with their probability allows for analysing risks. However, the definition of *wildfire risk* is inconsistent, the main difference being whether the risk describes the likelihood of a fire occurring or of potential consequences. In DRR science the occurrence of fires would be referred to as *fire hazard* and potential consequences as *fire risks* [138]. In fire science, the probability of fires occurring used to be referred to as ‘*fire risk*’. However, there are growing efforts of including exposure and vulnerability into risk assessments and to introduce the term ‘*fire danger*’ for the likelihood of fire hazard occurrence [10]. So far, *fire danger* mostly refers to fire weather [69,160–162]. Notably, the strong link between fire weather and fire occurrence is above all valid in regions that are not limited by fuels [163] or ignitions.

Using fire-weather metrics alone in socio-economic risk assessments can lead to misleading interpretations of wildfire risk. For example, the 2023 report of the Lancet Countdown on health and climate change [98] provides future projections on people exposed to fire danger. The used Fire Danger Index is based on fire weather and its projections. Compared to the 1995–2014 reference, the number of days of being exposed to “very high or higher wildfire risk” is projected to increase by 11% or additional nine days per person. However, the authors also find a reduction in exposure to actual wildfires (or rather their emissions) in the historic time period (2003–2023, see Section 6.2), while more than half of countries experienced an increase in meteorological fire danger in the same time period [98]. This example underlines the importance of using precise terminology and transparently discussing the used fire metrics to describe wildfire risks. To support this, we streamline definitions and suggest using the terminology in Table 7.

Beyond analysing historic fire impacts with the best suited data set, the analysis of fire risks will require further research including efforts focusing on the three components of severity (impacts), hazard, exposure and vulnerability. Moreover, bridging the gap between scientific communities, including ecology, DRR and social science can play a central role in contributing to improving fire management.

Table 7
Suggested definitions around wildfire risks.

Term	Definition
Meteorological fire danger	Likelihood of fire occurrence in regions not limited by fuel, often described by the Canadian Forest Fire Weather Index System.
Fire occurrence probability	Likelihood of fire occurrence based on all fire controls (see Section 3).
Fire risk	Likelihood of potential fire-related impacts (combination of hazard x exposure x vulnerability).

7.1. Hazard: global observational and simulated fire data

The upcoming decommissioning of MODIS raises concerns about temporal inconsistencies in long-term fire records and underscores the need for harmonisation between MODIS and VIIRS data products. In addition, the operationalisation of event-based fire products would greatly facilitate their use in DRR applications. Sub-daily datasets such as FEDS¹⁰ [109] offer promising opportunities to improve our understanding of impact-driving extreme fire behaviour.

Furthermore, the spectral characteristics of urban fires may differ markedly from those of wildland fires, for which most detection algorithms have been designed, suggesting a need for complementary detection approaches tailored to urban environments. Finally, while reliable methods exist to exclude agricultural fires (e.g., GloCAB, MODIS land-use layers), comparable records for prescribed burns are still limited. A promising recent effort is GlobalRx, which compiles prescribed-burn information for 16 countries [44].

The rather short global fire records spanning roughly 20–25 years, might both miss places with longer fire return intervals (>50 years), as well as fail at describing the probabilistic nature of risk. This underlines the need for fire models. The development of global fire hazard models is hampered by differing drivers and characteristics between fire regimes (see Section 3). Moreover, the modelling scale has important implications on model components, requiring e.g. to account for fire spread explicitly [8]. Generally, more research on adequate resolutions for wildfire risk assessment is needed. Lüthi et al. [138] find that impact estimates are most reliable for resolutions less than 10 km. This underlines the coarse resolution of most process-based global fire models ($\geq 0.5^\circ$): The *Fire Model Intercomparison Project* [FireMIP, 164] brings together a range of coupled vegetation-fire models including LPJ-GUESS-SIMFIRE, which we discuss in Section 6.1. FireMIP is currently running projections in the frame of the *Inter-Sectoral Impact Model Intercomparison Project* [ISI-MIP, 165]. Analogous to the study conducted by Knorr, Arneth, and Jiang (see Section 6.1; [149]), the resulting burned area projections will allow for the comparison of projected exposed population and related uncertainties across models. However, given the coarse resolution of the burned area fraction [e.g. 1° in 149], it would be important to incorporate changing rates of rural and urban populations in future work [6]. Moreover, process-based models struggle with shortcomings in depicting inter-annual variability and extremes [166] and differ in their regional suitability. To overcome the latter, the different models can be weighted according to their agreement with regional observations [128]. Complementary, statistical modelling efforts require databases covering a range of different fire drivers to be trained on [167–169]. For example, the SeasFire Cube dataset provides 59 fire-relevant variables on 0.25° globally [170]. Lastly, expected changes in fire regimes make the incorporation of projections indispensable for a comprehensive risk assessment [171].

7.2. Exposure and vulnerability assessment

Although the analysis of vulnerability of different exposures (population, assets, ecosystems) is complicated by the paucity of impact records, we encourage further analyses on the causal links between remote-sensing derived fire extremes and impacts, in particular on regional to global scales. This includes relating FRP-derived fire intensities to impacts. However, other fire properties or risk factors might be more relevant for impacts: Structures surrounded by grasslands in California were found to be more vulnerable to fires, despite low fuel loads [172] and consequently generally lower fire intensities [68]. Simultaneously, fires in grasslands typically spread faster, potentially highlighting the relevance of fire spread for impacts. Studies on vulnerability factors of individual houses in the US [172,173] find topography and the arrangement of structures in space to be the most important predictors, outperforming vegetation covariates [173]. Also new building regulatory standards can have a positive effect on structure vulnerability [174]. Besides building materials, also fire suppression influences directly which houses are lost [173]. The central role of suppression in reducing impacts [7] highlight the relevance of considering coping capacities of communities in risk assessments [9]. Notably, suppression efforts are intensified when fire fronts approach homes, in particularly such of great value [125].

Studies on vulnerabilities can draw from examples presented in this review, e.g. on approaches calibrating impact response functions [e.g. 138,144]. Moreover, global datasets covering built-up areas [175] and in particular the WUI lend themselves for analysing the vulnerability of these fire-prone areas, e.g. those provided by Schug et al. [10 m resolution for the year 2020, 176] and Tang et al. [9 km resolution for the years 2001–2020, 177].

¹⁰ The Fire Events Data Suite (FEDS) is operationally available on FIRMS under the name “VIIRS modeled fire perimeters” for Canada and CONUS: https://firms.modaps.eosdis.nasa.gov/descriptions/FEDS_VIIRS_SNPP.html.

The increase in devastating fires and the apparent drawbacks of a suppression focused management call for a paradigm shift in fire management from fire suppression to hazard mitigation [1,126]. This new paradigm would include not only aiming at reducing the total fire extent but also at considering potential impacts in management choices [126]. Complementary disaster responses (Fig. 1 black outer lines) include emergency alerts and protective actions such as evacuations [1] or sheltering in place [9] in the short term and adapted land management strategies in the long term [1]. The use of managed fires further underlines the necessity of an integrated risk management including land-use planning and raises questions on land ownership and the interplay between public and private stakeholders [123]. This highlights the deeply interdisciplinary nature of this natural hazard, which spans from natural to social science.

8. Conclusion and summary of recommendations

Wildfires — and, increasingly, urban fires — constitute a growing hazard for DRR, and remote-sensing data provide the most comprehensive basis for their global assessment. Yet a systemic approach (Fig. 1) is needed to account for regionally varying risk factors and to support the identification of appropriate adaptation options.

Burned area products are generally used to estimate the extent of burned land. Using them to quantify exposed natural and human values constitutes a rather upper estimate [3], as not all fires cause total local destruction. Managed fires can be excluded by using land use data [e.g. MODIS agricultural land, see 133] or records of prescribed burns [44]. Active fire detections provide a proxy for fire intensity, however, caution is warranted in intensity metric selection, as available observations are characterised by latitudinal differences and biome dependence. When using FRP, we recommend using the 95th percentile to approximate maximum fire line intensities [56]. We suggest computing this metric either per fire event [3], or on an impact-relevant scale, e.g. 4 km [138]. In addition, uncertainties can be reduced by excluding measurements with a large scan angle ($>50^\circ$), low confidence ($<30\%$) as well as by normalising FRP values by pixel size [146]. Alternatively, event-based fire products offer key fire behaviour metrics, such as rate of spread [132] and fire line intensity [66] — while they are limited by irregular update cycles. When quantifying fire effects on population, also smoke exposure should be considered. We recommend using smoke plume model outputs, as well as WMO thresholds [$PM_{2.5} \geq 15 \mu\text{g m}^{-3}$, reference 120]. Quantifying impacts on ecosystem needs to be combined with an understanding of their natural fire regime as well as the ecological value in question. Generally, burn severity metrics are likely most suitable for their analysis [74].

Taken together, these considerations underscore the importance of selecting fire metrics that align with the process of interest, the spatial and temporal scale of analysis, and the ecosystem or value being assessed. No single dataset captures all dimensions of wildfire risk, but understanding their strengths and limitations enables more accurate and transparent assessments. With this review, we aim to strengthen the engagement of the DRR community in the ongoing shift towards holistic fire management. By clarifying fire data options and highlighting key uncertainties, we hope to encourage interdisciplinary collaboration and contribute to more resilient societies that are better prepared to coexist with wildfires.

CRediT authorship contribution statement

Carmen B. Steinmann: Writing – review & editing, Writing – original draft, Visualisation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualisation. **Jonathan Koh:** Writing – review & editing, Conceptualisation. **Rebecca C. Scholten:** Writing – review & editing, Conceptualisation. **David N. Bresch:** Writing – review & editing, Supervision, Conceptualisation. **Stijn Hantson:** Writing – review & editing, Supervision, Conceptualisation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The used data repositories are referenced in the manuscript.

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