Searching the flames:
trends in global and regional public interest in wildfires

Abstract

The interaction between humans and wildfires is increasing in many regions driven by climate and land uses changes. A shift towards more adaptive fire management and policies is urgently needed but remains difficult to achieve. A better understanding of public interest in wildfire can facilitate this transition, as the public is a key driver for policy and management decisions. We used Google Trends to assess temporal patterns (2004-2020) in public interest on wildfires worldwide and in five case study countries (Australia, Canada, Indonesia, Portugal and USA). Public interest consistently shows a cyclic pattern with low background and short-lasting spikes during fire seasons and catastrophic events. The wildfires that receive most interest worldwide are located in Western countries, especially in the USA, and there is usually a high demand for news on the topic when spikes in interest happen. Overall global interest in wildfire has risen markedly since 2017, probably triggered by a series of catastrophic fire events around the globe. Nevertheless, public interest in wildfire is low when compared with socioeconomically more costly earthquakes or hurricanes. The short and seasonal interest of the public to wildfire may present an important obstacle to the implementation of wildfire mitigation policies that require year-round approaches; however, the fact that the public uses the internet to obtain basic knowledge about wildfire functioning and impacts, especially during the interest spikes, can facilitate targeting awareness campaigns not only about wildfires, but also about broader related environmental issues, such as climate change.

Keywords: google trends, forest fires, bushfires, natural hazards, wildfire impacts, social perceptions.

1. Introduction

Current changes in climate and land uses are increasing the interaction between humans and wildfires in many regions around the world; sometimes with catastrophic consequences. Anthropogenic changes in climate and land uses are causing wildfires to be larger and more severe in some fire-prone areas (e.g. Western USA or Australian forests) and more common in other regions where wildfires used to be rare (e.g. Amazonia or the Arctic) (Canadell et al., 2021; dos Reis et al., 2021; Jones et al., 2022; Voronova et al., 2020). Projected increases of severe fire weather (i.e. favourable meteorological conditions for the start and spread of fire) and the growth of the wildland-urban interface (i.e. built up areas surrounded by vegetation) are expected to exacerbate this fire problem even more in the near future (Jones et al., 2022; Radeloff et al., 2018; Son et al., 2021).

Over the last few years, catastrophic wildfires have occurred across the word, attracting substantial media and public attention. The label 'catastrophic' has been given for a range of reasons: their rarity (e.g. wildfires in the Artic in 2020; Witze, 2020), their unprecedented extend (e.g. the Black Summer bushfires in Australia in 2020/21; Bowman et al., 2021), their environmental impacts (e.g. deforestation fires in the Amazonia in 2019; Silveira et al., 2020) or their toll on human lives and the economy (e.g. Attica fires in Greece or the Camp fire in the USA, both in 2018; (CalFire, 2022; Lagouvardos et al., 2019). Most wildfires are not catastrophic, however, and it is important to recognise that wildfires and intentional land management fires together burn approximately 4% of the global vegetated land every year (Doerr and Santin, 2016). Indeed, wildfire is an intrinsic, often essential, perturbation in many ecosystems and thus a widespread natural hazard with which we must (re)learn to co-exist(Moritz et al., 2014). This fundamental message is widely accepted within the wildfire scientific and management communities; however, it has not fully reached society and policy makers, many of whom still perceive wildfires as events that can and should be fully eliminated (Cochrane and Bowman, 2021; Doerr and Santin, 2016; North et al., 2015).

Public interest and awareness are strong drivers of policy and management decisions (Macallum et al. 2013; Pissolito et al., 2020) and they, also, influence wildfire activity (e.g. via arson and accidental ignitions) and impacts (e.g. via wildfire preparedness or mitigation). Indeed, there is a growing body of research examining the interest in and perceptions of specific communities or stakeholders to wildfires and associated issues (e.g. Berglez and Lidskog, 2019; Ghasemi et al., 2020; Kouassi et al., 2022; Larsen et al., 2021; Palaiologou et al., 2021; Rosenthal et al., 2021; Sahar et al., 2018; Troumbis, 2021). For example, following the extreme fire seasons of 2017 and 2018 in California, Rosenthal et al. (2021) found that mental and emotional well-being and access to health resources were perceived as the most challenging health concerns that survivors face post-disasters. Following the largest forest fire in Sweden's modern history (2014), (Lidskog et al., 2019)found that the public placed little blame on forest companies and fire departments even so it was human-caused, and there was a belief that organizations will learn from it and take action to limit future wildfires.

Such case studies are very insightful in reflecting local and regional perceptions, however, larger-scale and longer-term studies on public interest on wildfires have not been conducted to date, leaving a clear research gap especially at national to global scales. These types of studies have traditionally been very challenging to carry out even at national or finer scales, relying on methods such as face-to-face, telephone, or email surveys, which require considerable time and resources and are subject to nonresponse bias and insincere answering (Mccallum and Bury, 2013). In recent years, internet search data mining has emerged as a powerful alternative tool to estimate public interest. Its main advantages compared to the traditional methods are the typically very large sample size, low cost, anonymity, and high temporal frequency. It is therefore viewed as being more effective than traditional surveys at tracking the public's interest (Burivalova et al., 2018).

In this study we employ internet search data mining with the overall aim to address the research gap identified above: the lack of large-scale and long-term studies on public interest on wildfires. We use Google Trends (GT) to evaluate the long-term (17 years; 2004-2020) trends in public interest in wildfires, both at global and national (Australia, Canada, Indonesia, Portugal and USA) levels. We also explore to what degree public interest is aligned with the geographical and temporal distribution of wildfire; i.e. how temporal and regional trends in web search interest relate to specific wildfire events or other indicators of wildfire occurrence and impacts (area burnt, economic impact, number of casualties). Furthermore, we compare the interest in wildfire with that in other natural hazards and, also, analyse Google's advanced searches by images, news, and videos. Finally, we use GT information to identify the main issues the public is interested in when searching for wildfire-related information on the Web.

2. Materials and Methods

2.1 Google Trend Data Mining

Google Trends (https://trends.Google.com/trends/) is a publicly available repository on real-time web user search patterns of individuals that use Google as their search engine. It provides topic/keyword-related data, including search volume index and geographical information about search engine users. It is freely accessible and can be used for comparative topic/keyword search, to discover event-triggered spikes in topic search volume, and to assess how interest in a keyword/topic has changed over time (Burivalova et al., 2018). Trends and changes in the search behaviour by the public are closely tied to their interests, and those interests are critical to driving public policy(Mccallum and Bury, 2013; Oehl et al., 2017). GT has already been used to track the level of public awareness and interest about some key environmental issues such as sustainability, nature conservation, climate change or invasive species (Anderegg and Goldsmith, 2014; Andrew et al., 2016; Fukano and Soga, 2019; Kovalenko et al., 2021; Proulx et al., 2014; Troumbis, 2021), and some natural hazards such as earthquakes, droughts or rip currents (Habibi and Feld, 2018; Houser et al., 2019; Kam et al., 2021; Kim et al., 2019). GT's main constraint is that it shows relative (i.e. not absolute) search-term frequency, therefore, whilst being very effective for detecting spikes or temporal patterns, interest is quantified in relative, but not absolute terms(Burivalova et al., 2018). Furthermore, what motivates internet users to search for each term is not known, so one can assume interest but, for example, cannot derive from those data specific views or behaviours (Ripberger 2011). Notwithstanding these limitations, the validity of GT data is well supported in the literature(McCallum and Bury, 2014) and GT is emerging as one of the best proxies for gauging public curiosity, attention, and issue salience (Mccallum and Bury, 2013; Mellon, 2014; Vosen and Schmidt A, 2011).

Here we used GT to assess the public interest in wildfire, as well as temporal and spatial trends on this search interest(Anderegg and Goldsmith, 2014; Moustakas, 2021; Turki et al., 2020). To do this, we analysed the use of 'wildfire' as a search topic in Google searches from January 2004 (first date from which GT information is available) to February 2020 (both months included). The use of wildfire as a search topic, not as a word, ensures that results exclude those searches with the word 'wildfire' but where it refers to other contexts (e.g. wildfire songs or wildfire in the TV series Games of Thrones). In addition, when considering the 'wildfire' topic, synonyms such as 'bushfires' or 'forests fires' are also included, allowing a more comprehensive inclusion of searches. Also importantly, our analysis included web searches in all major languages covered by Google translator.

In GT, data are averaged per month. First, the absolute number of searches for the specific topic (i.e. wildfire) relative to the total searches in the specific location and time is calculated. For this, GT data is pulled from a random, unbiased sample of Google searches. Then, to provide specific values, the data are indexed from 1-100, where 100 is the maximum search interest for that topic in the selected location over the study period. This index is known as the Relative Search Interest (RSI) or Volume and ranges from 0 to 100%, with 100% being the specific time when the highest relative search volume was recorded for this topic (Anderegg and Goldsmith, 2014). The fact that all the data are given in percentage eliminates any bias from the fact that the total number of internet users and, thus, the number of searches, have increased over time (see Section 3.6).

Data on search interest in wildfires for the study period was obtained both worldwide as well as for five case study countries (results in Section 3.1). Searches per country were defined by the IP location during the search date of devices performing web search of the term. The countries selected were Australia, Canada, Indonesia, Portugal and the United States of America. These countries all experience wildfires frequently and extensively, have had major fire incidents in the study period, and cover a range of world regions, biomes, and fire regimes.

Given that GT allows multiple topics to be queried simultaneously, with their RSIs provided relative to the topic with the highest total number of searches, this allows comparison of relative interest among different topics. Therefore, to compare the interest in wildfires versus other major natural hazards, data were mined from GT during the same study period and countries, including globally, comparing the topics "Drought", "Hurricane (= tropical cyclone)", "Earthquake", "Storm" and "Wildfire". This natural hazard comparison was done both at global and at country level including all countries, not only our five case study countries (results in Section 3.3).

In addition, overall RSI over time was also compared to the relative search interests on the wildfire topic generated by using Google's advanced searches by images, news, or videos. This tool is only available for searchers from January 2008 onwards (results in Section 3.4). Finally, GT also provides information regarding the most frequent types of queries related to a word, which we also obtained for wildfire Google searches at the global level (results in Section 3.5). This specific tool of GT does not allow to look by topic but by word. Therefore, once the wildfire query types were obtained, those not related to the topic, but to the word wildfire in other contexts were manually removed (e.g. videogames, songs, Games of Thrones, etc.). Unlike the other GT tools used here, this particular one only covers search queries typed in the English language.

2.2 Fire Occurrence and Impacts Data

Global and national (for the five case study countries) fire activity data were provided by the European Forest Fires Information System (EFFIS; https://effis.jrc.ec.europa.eu). Monthly area burnt for the globe, Australia, Canada, Indonesia, Portugal and the USA was derived from the MODIS burned area product MCD64A1, which identifies burned areas globally at a 500 m pixel spatial resolution(Artés et al., 2019). This information is available from the year 2002 onwards and, therefore, covers the whole study period.

Data on fire impacts (economic losses, number of people affected and number of deaths) was extracted from the Emergency Events Database (EM-DAT; Université catholique de Louvain (UCL) - CRED, D. Guha-Sapir - www.emdat.be, Brussels, Belgium). EM-DAT provides open access data on the occurrence and impacts of over 22,000 natural and technological disasters, including wildfires, in the world from 1900 to the present day. The database is compiled from various sources, including UN agencies, non-governmental organisations, insurance companies, research institutes and press agencies. For an event to be included in EM-DAT it needs to fulfil one or more of the following four criteria: (i) 10 or more people dead, (ii) 100 or more people affected, (iii) declaration of a state of emergency or (iv) call for international assistance. It therefore does include key events, but not all damaging fire events, so lives lost, and economic damage based on EM-DAT reported here are likely to be an underrepresentation of actual global values. Correlations between worldwide and country-level RSIs and these fire occurrence and impact indicators were performed (see Section 3.2).

2.3 Statistical Analysis of Google Trend Data

In order to examine the seasonal (i.e. months within each year) patterns of global interest in wildfires, time series decomposition was performed. This approach separates the time series into linear trend and seasonal components, as well as error and stochastic fluctuations (West, 1997). As the seasonal pattern in the data depended on the level of the data (i.e. more searches are likely to be carried out during months with active fires) a multiplicative model structure was employed accounting for this effect (Moustakas and Evans, 2016). A multiplicative detrending model was used when the size of the seasonal pattern in the data depended on the level of the data. The analysis resulted in four indices: seasonal indices, original data by season, percent variation by season, and residuals by season. In addition, change point detection algorithms (e.g.Moustakas and Evans, 2016)) were employed to detect changes in both the mean and variance of the global search interest in wildfires per month analysed as time series. The binary segmentation test statistic was used to detect changes in the data (Scott and Knott, 1974). Change point detection methods allow the decomposition of complex non-stationary time series into segments where the mean and variance are constant, and thus such changes can be quantified. Lastly, Spearman's rank correlation coefficients (r_s) were calculated to identify monotonic relationships between variables, using a level of significance of 5%. The following descriptors for associations based on the r_s values were used: very strong: >0.8; strong: 0.8-0.6; moderate: 0.6-0.4; weak: 0.4-0.2; very weak-none: <0.2.

3. Results and Discussion

3.1 Temporal Trends of Public Interest in Wildfires

3.1.1 Global trends

The global relative search interest (RSI) shows a low background level with frequent short-lasting spikes. The global temporal trend is very cyclic (Fig. 1), mostly peaking every year between June and September, which are the months corresponding to the summer fire season in the northern hemisphere (Fig. 1 and Fig. S1). There are, however, notable exceptions to that pattern, which correspond to spikes related to wildfires that have happened outside of the northern hemisphere summer season. Most of these exceptions are catastrophic fires that have happened in California, for example in October 2007, October and December 2017, or October and November of 2018 (Fig. 1). There are also some peaks related to fires outside of the USA, for example, the Australian bushfires during the northern hemisphere winter of 2019/2020 or the Fort MacMurray (i.e. Horse River) wildfire in Canada in May 2016. Overall, however, events outside the USA seem to attract less global attention. For example, the Black Saturday fires in Australia in February-March 2009, which have been the deadliest globally in recent history with 173 direct fatalities, resulted only in a minor spike in the global RSI. This also applies to the Pedrógão Grande wildfire in Portugal in June 2017, with 66 deaths but a low global RSI (Fig. 1).

There was a significant rise in wildfire search interest during the last four years of the study period (Fig. 1). The change point detection algorithms indicate a change in the mean and variance of the time series in June of 2017. For the first segment of time series (Jan. 2004- June 2017), the mean RSI was 26%, whereas for the second part (Jul. 2017 – Jan. 2020) it increased to 42% (Fig. 1). This increase in wildfire search interest during these last few years is probably related to a higher occurrence of catastrophic events in several regions of the word, especially North America (see Section 3.2.2.; Iglesias et al. 2022). Indeed, there has been a several-fold global increase in the insured losses from wildfires since 2017 (Bevere and Weigel, 2021).

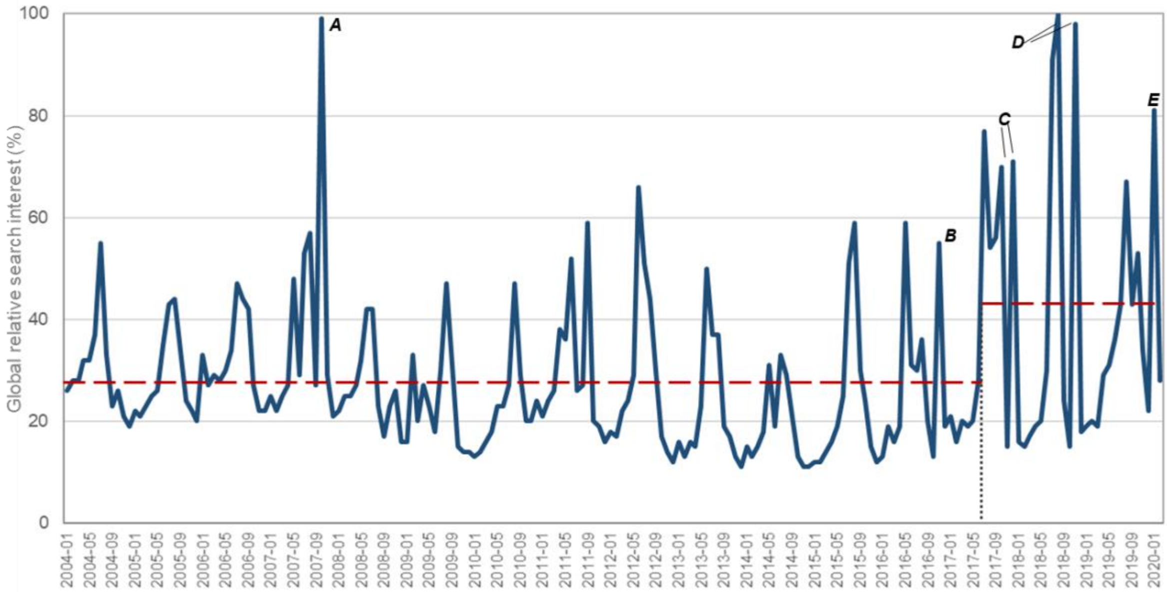

Figure 1. Temporal evolution of the global relative search interest from Jan. 2004 to Feb. 2020. The vertical black dotted line shows a change point in the mean and variance of the data on Jun. 2017 (see Section 3.1.1). The dotted red line shows the mean of the data within each of the two change-point segments. Capital letters A-E identify alignment with specific fire events discussed in Section 3.2.1 [A: Oct. 2007 California; B: Nov. 2016 the Great Smoky Mountains wildfires, Tennessee, USA (and Israel); C: Oct. and Dec. 2017 California (and Portugal in Oct.); D: Aug.-Nov. 2018, California; E: Jan. 2020 Australian Black Summer Bushfires].

To explore the relationship between global RSI and quantitative indicators of global wildfire activity and impacts, we compared the RSI trends to those for global area burnt, number of wildfire disasters, economic costs, number of people affected and number of deaths (see Section 2.2 for details). Only moderate to weak correlations were found between global RSI and these variables (see Fig. 2 and Tables S1 and S2).

Burnt area is a widely used parameter to describe trends and patterns in fire activity (e.g. Andela et al. 2017); however, only a weak correlation was observed between global area burnt and public interest (Fig. 2A and Table S1). This is not surprising as a substantial fraction of the area burnt worldwide every year is in remote or sparsely populated regions (e.g., tropical savannas or boreal forests; Jones et al., 2022). Those fires are rarely picked up by the media or draw general attention, as they do not usually lead to substantial impacts on humans and assets (Doerr and Santin, 2016).

Global search interest did show somewhat stronger correlations with the descriptors of wildfires impacts on humans studied here, although only ranging from weakly to moderately, (i.e. number of wildfire disasters (r_s: 0.44) > number of people affected (r_s: 0.37) > economic damage (r_s: 0.32) > number of deaths (r_s: 0.30); Fig. 2B and Table S2). The lack of stronger correlations may be, at least in part, due to the fact that global RSI is not spread equally around the globe, due to lower internet penetration (i.e. portion of the population that has access to the Internet) in less developed countries(Pew Research Center, 2019). Hence not all catastrophic events receive the same amount of global interest. For example, for other natural disasters (earthquakes), it has been demonstrated that overall global interest is higher when they occur in developed countries than in developing countries (Kam et al., 2021).

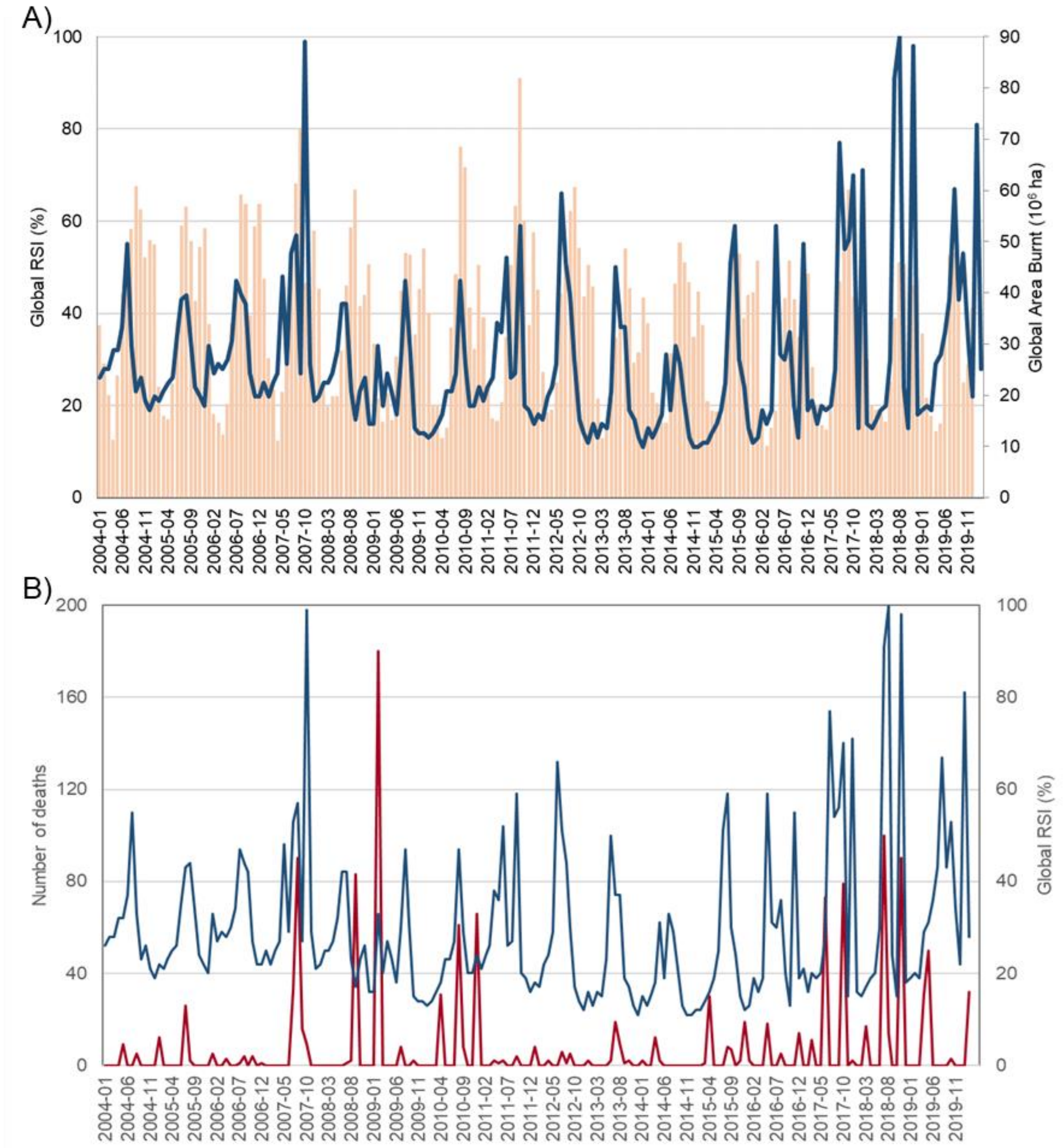

Fig. 2. A) Temporal evolution of global area burnt (red bars, right Y axis) and global relative search interest (blue line, left Y axis). B) Temporal evolution of global relative search interest (red line, right Y axis) and global total deaths (blue line, left Y axis).

3.1.2 Trends by country

In addition to global trends, the temporal evolution of RSI was examined for five selected case study countries: Australia, Canada, Indonesia, Portugal and the USA. This selection covers a wide geographical range, and all these countries present high fire activity and have been affected by catastrophic wildfire events in the study period. All countries present a similar pattern to that observed for the global RSI, with a low interest baseline with intermittent spikes of high RSI (Fig. 3). These temporal spikes in interest, however, vary greatly between the five case study countries, with very few spikes occurring at the same time in several countries. This points to each country-level RSI being driven mostly by national events (see Fig. 3 caption).

For all the case study countries, the baseline is lower than for the global RSI (Fig. 1 vs. Fig. 3). This seems to indicate that be global RSI is driven by many different countries and, therefore, by fire seasons and events that do not overlap in time. It is notable that the highest RSI for the five studied countries occurred within the last four years, the period identified as having the highest global average RSI interest (see Section 3.1). The case of Canada is especially relevant as it had a very low RSI over the first ten years of the study period (2004-2013), but search interest grew markedly in the last 5-6 fire seasons. This aligns with an observed climate-change influenced increase in fire activity and associated impacts in Canada and other forest dominated boreal and temperate regions (e.g. British Columbia fire seasons of 2017 and 2018; 2016 Fort McMurray wildfire; 2019-2020 Black Summer in Australia; .Canadell et al., 2021; Kirchmeier-Young et al., 2019).

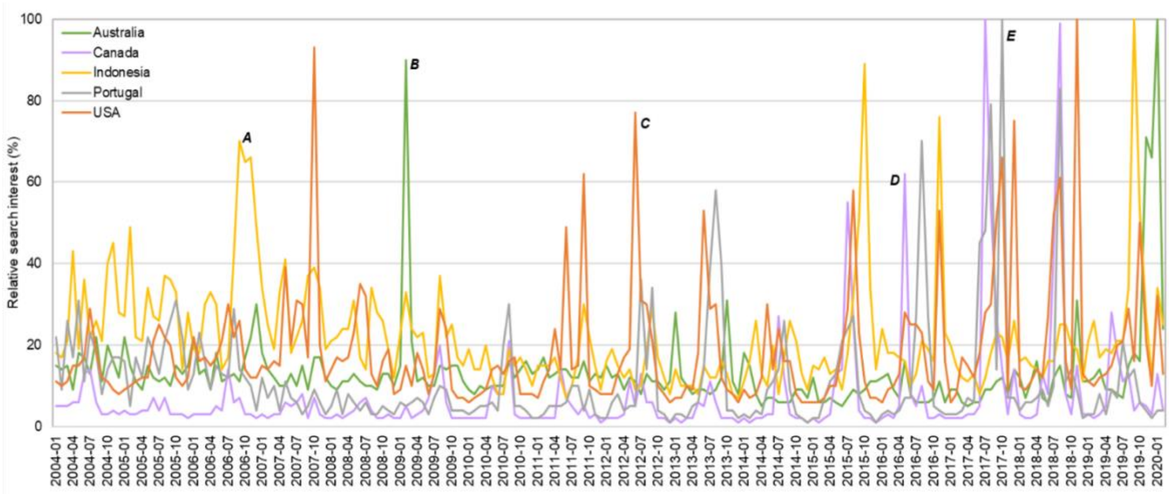

Figure 3. Temporal evolution of the relative search interest from Jan. 2004 to Feb. 2020 for the five case study countries. A-E identify fire events aligned with spikes of RSI at national level, but not in other countries or at global level [A: Aug.-Nov. 2006 Indonesian fires, B: Feb. 2009 Australian Black Saturday fires; C: Jun. 2012 Colorado wildfires, USA; D: May 2016, Fort MacMurray fire, Canada; Oct. 2017, Iberian wildfires, Portugal].

When comparing the global with the country-level RSI temporal patterns, the closest similarity is shown by the USA with most spikes in interest there matching those found at global level. This close association does not apply so clearly to the other four countries studied (i.e. Australia, Canada, Indonesia and Portugal) (Sup. Fig. S2). Correlations between global and country-level RSIs corroborate this, with the correlation between global and USA RSIs being the strongest (Table S1). This is at least in part, due to not all the fire events in USA that sparked interest both at national and global level, having had the same effect in the other four studied countries. Conversely, in the cases of Australia, Indonesia and Portugal, there were local events leading to RSI spikes in those countries but not at the global level (Sup. Fig. S2). Some examples of those are the already mentioned 2009 Black Saturday bushfires in Australia, the Iberian wildfires in Portugal in October 2017 or the 2006, 2015 and 2019 Southeast Asian haze seasons triggered by wildfires in Indonesia (Fig. 3). Regarding Canada, major fire events here seem to trigger a global response even when these events do not trigger such a strong response in the USA (Sup. Fig. S2). The relatively higher global interest in catastrophic Canadian fires over those in Australia, Indonesia or Portugal is challenging to explain. It could be due to a mix of a "developed country bias" (i.e. disasters in countries with higher GDP per capita attract more public attention; Habibi & Feld 2018) and, also, due to "distance bias" (the likelihood that a disaster is covered by the media depends on the distance between the country where the media are located and the country where the disasters occur; (Berlemann and Thomas, 2019). This would affect mostly the interest from the public in the USA (note that USA and Canada RSIs are strongly correlated, Table S1). Another contributing factor might be a bias in the GT method, if English speaking searches were somehow better identified than those performed in other languages. However, the search by 'topic' instead of by word should in principle overcome this problem (see Section 2.1). Moreover, that possible bias does not agree with the fact that some of the main wildfire disasters in Australia, also an

English-speaking country, are not reflected in the global RSI. Another possibility is a methodological bias toward the word 'wildfire' (widely used in North America) compared to other synonyms (e.g. bushfire, commonly used in Australia). Unfortunately, GT algorithms are not public and, therefore, it is not possible to corroborate or refute these methodological bias hypotheses.

We also explored potential associations between RSI and area burnt at the national levels (Table S1). In contrast to what is observed at the global level, correlations found were strong at country level for Canada (r_s: 0.72), USA (r_s: 0.61), and Portugal (r_s: 0.61). For Indonesia, this correlation was only weak (r_s: 0.38). Interestingly, no correlation between area burnt and national RSI was found for Australia, which may be attributed to the fact that area burned here is dominated by frequent burning of savanna grasslands in northern Australia, rather than the more destructive forest fires of south-eastern and south-western Australia (Russel-Smith and Yates 2007). These grassland fires have little direct impact on human populations and are thus not particularly newsworthy (Doerr and Santin, 2016).

3.2 Comparisons with other Natural Hazards

To evaluate the search interest in wildfires within the broader context of natural hazards, global RSI for wildfire was compared to that of four other globally relevant natural hazards: earthquakes, hurricanes, storms, and droughts. The most internet searched natural hazards at the global level are earthquakes and hurricanes, followed, to a lesser extent by storms, and then by droughts and wildfires (Fig. 4). Regarding global temporal trends over the last 16 years, the low RSI for drought and wildfire when compared to the other natural hazards (always <3%; Fig. 4) does not allow a meaningful description for these two.

For hurricanes, earthquakes and storms, their RSI follow more distinct patters. Hurricanes, which have the highest RSI, present a cyclic pattern, similar to the one observed for wildfires (section 3.1). The background level is very low outside of the Atlantic hurricane season (<5%: Fig. 4), that typically falls between August and November, peaking in September. The global interest seems to be predominantly driven by catastrophic hurricanes affecting the USA, such as the Hurricanes Ivan (2004), Katrina (2005) and Harvey (2017) (Fig. 4). For earthquakes, the RSI background level is higher than for hurricanes, with spikes not following a seasonality, which is expected given that earthquakes do not normally fall into a specific season. In contrast to hurricanes, the interest in earthquakes is driven by catastrophic events all around the world (Fig. 4). Regarding storms, spikes are not as pronounced as for hurricanes and earthquakes (Fig. 4). This may be because, in the global context, storms are more widespread events both geographically and throughout the year compared to some of the other natural hazards studied. They are also more frequent and generally not as damaging per individual event as hurricanes or earthquakes. It is, however, notable that there has been an increase in RSI for storms over time (Fig. 4), what may be associated to recent increases of heavy precipitation over many regions worldwide, related to human-induced climate change (Douville et al., 2021)

The relatively low public search interest in wildfire compared to earthquakes and hurricanes may be related to the fact that the socio-economic impacts of the latest are usually higher. For example, the costliest wildfire disaster in history, the Camp Fire, had $17 billion associated losses (USA, Aug. 2018; Peak D in Fig. 1)(Munich Re, 2018), whereas the costliest hurricanes have been Hurricanes Harvey (USA, Aug. 2017) and Katerina (USA, Aug. 2005) with $125 billion losses each(NOAA, 2018). The costliest earthquake in history by far has been the Tōhoku Earthquake and Tsunami (Japan, March 2011) with $198-309 billion estimated losses (Mimura et al., 2011).

Accepted manuscript version of: Santin C, Moustakas A & Doerr SH (2023) Searching the flames: trends in global and regional public interest in wildfires. *Environmental Science and Policy, 146, 151–161* (*doi.org/10.1016/j.envsci.2023.05.008*)

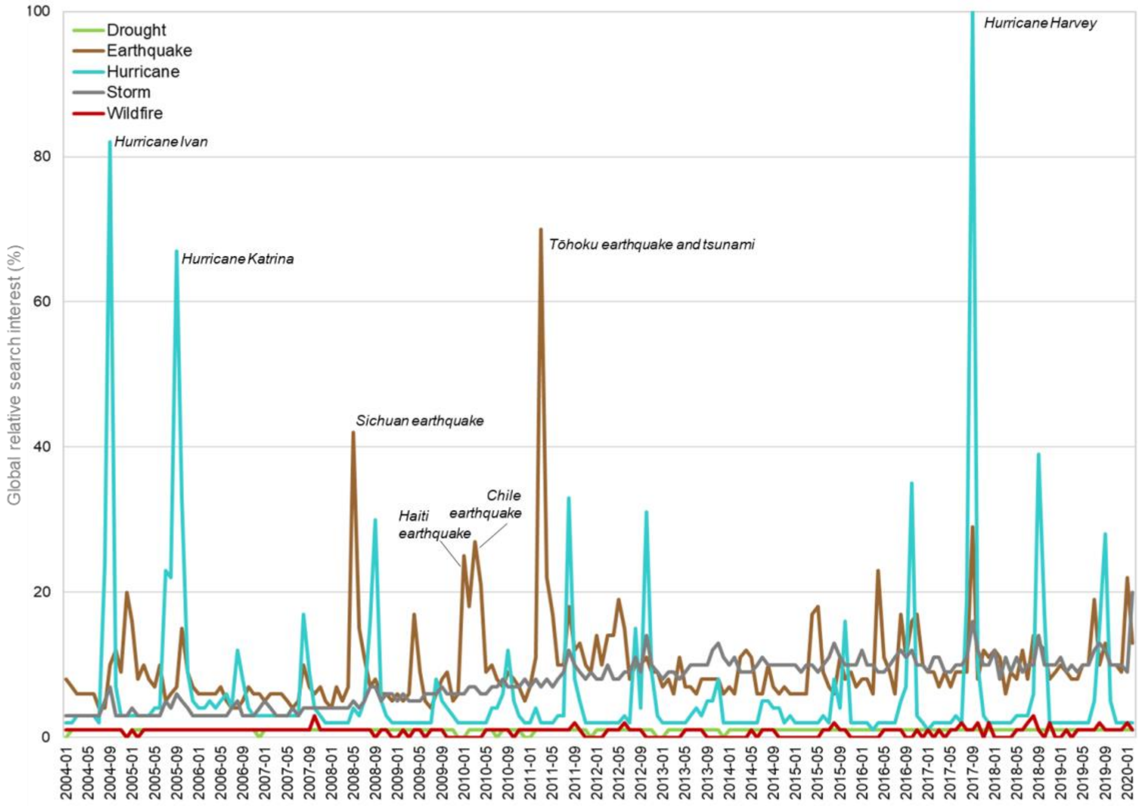

Figure 4. Temporal evolution at the global level of the relative search interest for the five natural hazards studied from 01/2004 to 02/2020. Specific major events are identified that align with RSI peaks. For hurricanes, several hurricanes may have happened around a specific date but only the name of the costliest one is shown here.

The natural hazard comparison was also done at the country level (for all countries, not only our case study countries; see Methods in Section 2.1). No country has wildfire as the top natural hazard in their Google searches (Table 1). Search interest for wildfire is low when compared to the other four natural hazards studied, with wildfire RSI always less than a third of the RSI value attributed to the most searched natural hazard in each country. Canada has the highest RSI for wildfire when compared to the other natural hazards studied here (31%; Table 1), which matches the fact that the 2016 Fort McMurray wildfire has been the costliest natural disaster in Canada to date (Tymstra et al., 2020). The second highest is Finland, followed by Portugal, Sweden and Germany (26-20%; Table 1). Of these countries, only Canada and Portugal have a high fire incidence, what indicates that the relative interest about wildfires in countries like Finland, Sweden or Germany may be related to the fact that the other natural hazards considered here are not very common in these countries. In addition, the fact that these countries have experienced some severe fire seasons over the last years, against a background of a historically limited fire occurrence, may also play a role (e.g. 2006 and 2018 in Finland; 2018 and 2019 in Germany; 2014 and 2018 in Sweden; Fernandez-Anez et al., 2021; San-Miguel-Ayanz et al., 2022).

	% Relative Search Interest				
	Wildfire	Drought	Hurricane	Earthquake	Storm
Canada*	31	6	100	69	72
Finland	26	19	84	94	100
Portugal*	25	84	56	100	47
Sweden	20	48	23	60	100
Germany	20	10	22	93	100
Netherlands	18	8	58	68	100
Austria	16	7	18	100	86
Indonesia*	14	6	3	100	17
Belgium	14	14	62	81	100
Denmark	13	9	27	73	100
Hong Kong	12	5	83	100	44
South Korea	11	7	18	91	100
Thailand	10	10	10	73	100
Switzerland	10	8	32	100	50
Australia*	9	18	82	100	94
Malaysia	9	4	35	100	70
United Kingdom	9	6	86	86	100
Spain	8	6	39	100	51
United States*	8	4	100	48	40
Singapore	7	4	51	100	60
Norway	3	7	7	16	100
Ecuador	2	1	8	100	8
Philippines	2	2	100	85	28
New Zealand	1	1	18	100	15
China	1	4	1	100	23
Chile	1	1	4	100	6
Turkey	1	0	2	100	5

Table 1. Relative Search Interest per country for the five natural hazards studied between Jan. 2004 and Feb. 2020. Note that for each country, the RSI values are relative (in %) to the natural hazard with the highest search interest. For a full list of countries see Table S3. *Case study countries in this study

3.4 Comparisons of general web searches with specific news, image or video searches

The temporal evolution of the global RSI via Google general searches was compared to specific Google searches for images, news or videos. In general, these specific searches follow similar trends although they do not always match closely (Fig. 5). For example, the spike in news and video searches in June-July 2008 was probably related to the 2008 Californian wildfires, but these fires did not generate a lot of general Google search interest. Similarly, one of the highest proportions of video searches occurred in August 2019, probably associated with fires in the Artic, but this period exhibits only a modest interest via general, news and image searches. The Australian 2019/20 bushfire season aligned with very high Google RSI and the highest spike in video searches with, for example, one video showing a woman washing the burnt hands of a kangaroo attracting over 1 million views (https://www.youtube.com/watch?v=KZa05ixGs1g). However, that period did not result in such a high proportion of news searches. On the other hand, there have been wildfire seasons that have driven a very high Google RSI, such as the Californian season of 2018, but have not generated such a high volume of news, YouTube or images searches (Fig. 5).

When examining the correlations among the different types of Google searches, we found that the strongest association occurs between general searches and news searches (Table S4), highlighting how public interest is linked with a demand or supply in news on this topic. The weakest correlations of general searches with searches for images and videos could indicate that people searching for the topic may be either fundamentally more interested in written information than in visual impressions or, simply, that in those instances there are no especially captivating images or videos that went 'viral'.

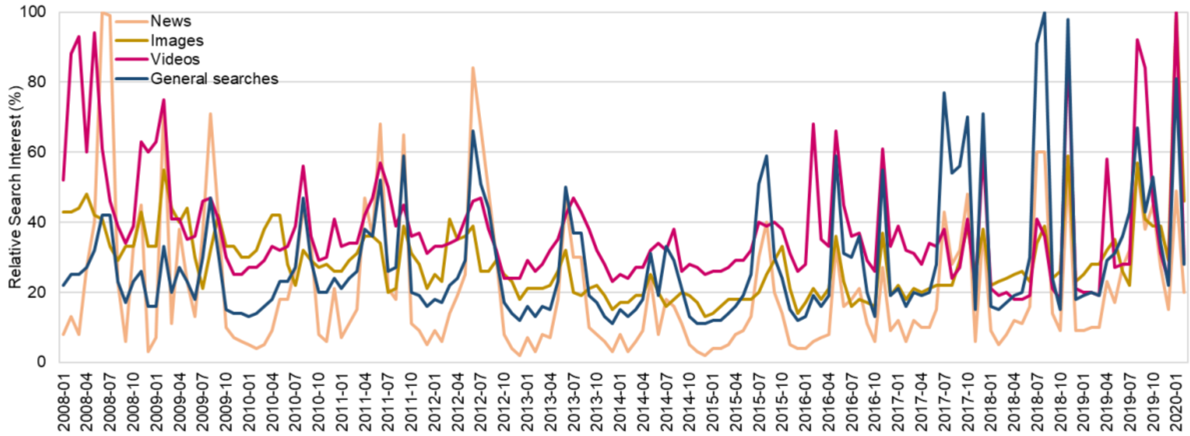

Figure 5. Temporal evolution at the global level of the relative search interest for general Google searches, and specific Google searches for images, videos and news within the wildfire topic, from Jan. 2008 to Feb. 2020.

3.5 What drives public interest?

In total, 160 query types related to the wildfire topic were identified (Table S5). The majority of them (56%) were related to the understanding of wildfire functioning. For example, where wildfires start, how they spread, why they happen or how they can be prevented. A smaller proportion (13%) were queries related to impacts on health, mostly related to questions about effects of smoke, such as 'why smoke is bad' or 'whether it can make you nauseous'. Other types of wildfire impacts, mostly regarding environmental effects, were are also searched for (9%). For example, 'what impacts wildfires can have on ecosystems' or 'what is the relationship of wildfire with water quality or climate change' (Table S5). A small number of query types (3%) were related to other matters such as 'what to do during a wildfire' or 'when to evacuate'. It is worth highlighting that a large proportion of all query types (39%) are about specific fire events, locations or periods of time, with around half of those being exclusively about these matters (e.g. ´wildfires near me today´) and the other half related also to the functioning type of questions highlighted above (e.g. 'why wildfires happened in Australia in 2019'; Table S5).

Accepted manuscript version of: Santin C, Moustakas A & Doerr SH (2023) Searching the flames: trends in global and regional public interest in wildfires. *Environmental Science and Policy, 146, 151–161* (*doi.org/10.1016/j.envsci.2023.05.008*)

In terms of the specific words used for wildfire-related Google searches, the world cloud in Fig. 6 displays those found in the query types identified. The most common words in the query types in descending order were smoke > cause > season > California > start > Australia = happen = occur. This corroborates that the public interest is focused on functioning of fire (e.g. 'cause', 'start', 'happen'), its health impacts (e.g. 'smoke') and specific locations with high populations and relatively frequent catastrophic fires (e.g. 'California', 'Australia'). It is important to note that the list of the most frequent queries related to wildfires contains no information about the specific frequency or total number of each of these. Therefore, the sizes of words in Fig. 6 are related to the number of queries they appear in among the total of 160 identified. They are not measurements of the number of Google searches with that specific word. It is also important to point out that the GT tool this information was extracted from only provides information on queries in English, and only for the word "wildfire" (i.e. it does not include other synonyms of the word or other languages as the other GT tools used in this study (see Section 2.1). Hence, the information provided comes exclusively from English-speaking users, who will be mostly based in English-speaking countries. Notwithstanding this, these specific results show that the public uses the internet to obtain basic knowledge about wildfire functioning/occurrence and their impacts and, specifically, also information on wildfires near to them.

Fig. 6. Word cloud generated using the key words (108) identified in the 160 query-types in the English language. Word sizes in the cloud are relative to the frequency each word was in the query dataset.

3.6 Limitations

GT is increasingly used to gather information about public interest for a range of topics, including environmental conservation and natural hazards (Anderegg and Goldsmith, 2014; Andrew et al., 2016;

Habibi and Feld, 2018; Kam et al., 2021; Kovalenko et al., 2021). It is a free-access tool which spatial and temporal reach is much broader than traditional surveying methods; however, it also comes with limitations, which are important to consider when drawing conclusions from its outputs.

Internet penetration varies among countries and individuals, with higher use in more developed countries. In addition, users of younger age and/or higher education/income have a higher probability of using the Internet, although the wealthier a country is, the more widespread the use of Internet is (Pew Research Center, 2019). Therefore, the global data here is biased towards more developed countries. Notwithstanding this, the reach of the internet has increased dramatically during our study period, from 17% of the world population in 2006 to 57% in 2019 (The World Bank, 2020). Its user profile has thus become more representative of the global population.

The fact that GT provides data from internet searches only with Google as search engine is also a limitation, although only a minor one given that Google is the most used web search engine in the world, with around two trillion searches per day (Arora et al., 2019). We can thus expect a good global representativeness except for internet-censored countries impacted by website filtering and/or promotion of alternative search engines, as in the case of China.

Regarding the sampling method, GT data are generated from a sample of searches made by users that Google describes as “random” and “unbiased”. Cebrián and Domenech (2022) demonstrated that GT data are robust in terms of completeness, consistency, and validity, but they found an issue in terms of accuracy, as the same queries do not always provide the exact same results. This sampling error cannot be quantified, as sampling methods are not disclosed by Google. However, Cebrián and Domenech, 2022) also found that the different time series generated are highly correlated and, therefore, this accuracy issue is not expected to substantially affect the type of analyses performed in the current study. In addition, the use of ‘topic’ in the current study instead of ‘key word’ should in principle avoid bias in terms of language or location (see Methods 2.1), but we cannot rule out that there may be some, unfortunately unquantifiable, bias toward searches happening in North America (see Section 3.1.2).

Lastly, it has been suggested that, as internet users and search volumes increase over time, trends detected with this tool might be caused by both genuine variation of search volume for the studied topic but also by variation of search patterns in other unrelated fields (e.g. decreases of searches for a given topic due to increases of searches for other topics) (Ficetola, 2013). The use of unrelated terms as benchmark have been suggested to identify trends that are not genuine, but we argue here that benchmark terms are not needed as GT normalizes and scales the search volume data, reporting already scaled rankings of percentages (McCallum and Bury, 2014).

4. Conclusions and implications for society, wildfire policy and management

To the author’s knowledge, this is the first study that quantitatively examined public interest in wildfire at the global level and it demonstrates that, in terms of internet searches, public interest in wildfires is on the rise. The rate of interest is not steady but follows a cyclic pattern with much higher interest during the northern hemisphere summer, i.e. its dominant wildfire season, and with the greatest interest spikes concomitant with specific catastrophic wildfire events or seasons. Therefore, the marked increase of interest in the last few years identified here (since 2017) is probably linked to the particularly high number of catastrophic wildfires that occurred around the world in this period, with many of them affecting densely populated areas in developed countries and resulting in substantial socioeconomic impacts (Bevere and Weigel, 2021; Iglesias et al., 2022; United Nations Environment Programme, 2022).

This pattern of a relatively low background interest with spikes around the period of a catastrophic event is also found for other natural disasters. Previous studies showed that public concern is often very high in the aftermath of a disaster, but it tends to decline and fade away over time (Anderegg and Goldsmith, 2014; Mondino et al., 2020). Public interest is critical in affecting public policy and actions (Mccallum and Bury, 2013) and we thus argue here that its cyclic pattern presents a key obstacle to more adaptative policies on disaster mitigation and management. This is especially acute for wildfires, as not only their impacts but also their extent and severity can be effectively reduced by all year-round awareness and mitigation actions (Cochrane and Bowman, 2021; Doerr and Santin, 2016; Moritz et al., 2014). Although these are often more effective than fire suppression activities, suppression, which takes place during the period with peak public attention, is still the strongest focus of resource allocation and associated policies (Moore, 2019; Tedim et al., 2020). On the other hand, fuel reduction burns, for example, which require public support due to their cost, smoke emissions and perceived ecological impacts, are a proven tool for reducing fire risk. However, they can only be performed during periods of low fire risk (i.e. usually outside of the main fire season), which is the period in which interest in fires wanes.

Recognising this challenge, the knowledge of cyclic interest can be taken advantage of in terms of policy and management, for example, by carrying out specific awareness campaigns, or implementing a regulatory chance towards safer building standards during periods when the population is more interested in the subject. Furthermore, these 'high awareness' periods can be a window of opportunity in cases, for example, where natural disasters affect a developing country and humanitarian aid may be needed (Kam et al., 2021)

In addition, our finding that a substantial proportion of the search queries on wildfires are related to wildfire occurrence, functioning and their impacts suggest that there is a demand for educational information by the public. This demand could facilitate, especially during the 'interest spikes', dissemination of information about wildfires and even about broader related environmental issues. Previous studies focusing on other natural hazards have found that public interest is more focused on more infrequent and more sensational hazards than in the most common and distributed ones (Houser et al., 2019). Also, environmental issues that tend to get more media attention are those which have immediate and drastic consequences. This is why climate change is so challenging to report on, as its impacts mostly occur over long-time scales which do not fit within the fast pace that media operate (Hopke, 2020). Considering this, catastrophic wildfire events could be utilized to educate the public about climate change and its environmental and socioeconomic consequences. Indeed, there is already an increasing trend of news reporting wildfires which also discuss the role of climate change in them (Hopke, 2020).

Our results further indicate that most of the catastrophic fires that drive the global interest occur in Western countries and, especially, in the USA. This matches the fact that USA has by far the greatest proportion of insured losses from wildfires (Bevere and Weigel 2021). Similar findings have been identified for other natural hazards. (Kam et al., 2021) reported that the global community shows a higher level of interest when an earthquake occurs in developed countries than in developing countries. This bias can hinder international responses to disasters in other regions of the world as it can make important events being overlooked. This was the case, for example, for the wildfires in Algeria in the summer of 2021, which caused over 90 deaths but went mostly unnoticed by the world (Bento-Gonçalves, 2021)

We also show a strong link between general public interest and search for news on the wildfire topic. Public interest often increases as traditional mass media and social media report disasters and spread the information 'regarding the pain of others' (Moeller, 2006). Therefore, disaster journalism is often more focused on the subjective emotional and storytelling aspects of the catastrophes than in reporting more objective and quantitative information, such as the number of deaths and economic losses (Cottle, 2013). In addition, wildfires are sometimes portrait as a 'spectacle'. This is a serious obstacle to the promotion of coherent risk governance and social learning, which involves recognizing wildfire risk as a social, political, economic, and environmental issue (Silva et al., 2019). On the other hand, media are integral to the 'cultural politics of the environment', and they are, therefore, key in the social construction of climate risk (Hopke 2020). We believe the research community has a duty towards this very pressing issue. When journalists and researchers work together, the information that reaches the public is more credible, scientifically-sound and nuanced (Smit et al., 2022). Fluid communication between fire research and the media is therefore essential to send the correct messages to society.

References

Anderegg, W.R.L., Goldsmith, G.R., 2014. Public interest in climate change over the past decade and the effects of the "climategate" media event. Environmental Research Letters 9. https://doi.org/10.1088/1748-9326/9/5/054005

Andrew, L., Arndt Daniel, Beristain N, Cass T, Clow T, Colmenares B, Damm K, Hatcher R, Jackson N, Pasquesi W, McCallum M.L, 2016. Changes in United States' Citizens' Interest in Sustainability (2001-2014). Life: The Excitement of Biology 4, 138–164. https://doi.org/10.9784/LEB4(3)Andrew.01

Arora, V.S., McKee, M., Stuckler, D., 2019. Google Trends: Opportunities and limitations in health and health policy research. Health Policy 123, 338–341. https://doi.org/10.1016/j.healthpol.2019.01.001

Artés, T., Oom, D., de Rigo, D., Durrant, T.H., Maianti, P., Libertà, G., San-Miguel-Ayanz, J., 2019. A global wildfire dataset for the analysis of fire regimes and fire behaviour. Scientific Data 6. https://doi.org/10.1038/s41597-019-0312-2

Bento-Gonçalves, A., 2021. Algeria suffers from devastating wildfires, but faces big challenges in addressing them. The Conversation.

Berglez, P., Lidskog, R., 2019. Foreign, Domestic, and Cultural Factors in Climate Change Reporting: Swedish Media's Coverage of Wildfires in Three Continents. Environmental Communication 13, 381–394. https://doi.org/10.1080/17524032.2017.1397040

Berlemann, M., Thomas, T., 2019. The distance bias in natural disaster reporting–empirical evidence for the United States. Applied Economics Letters 26, 1026–1032. https://doi.org/10.1080/13504851.2018.1528332

Bevere, L., Weigel, A., 2021. Natural catastrophes in 2020: secondary perils in the spotlight, but don't forget primary-peril risks. sigma 1/2021. Swiss Re Management Ltd Swiss Re Institute Zurich Switzerland.

Bowman, D.M.J.S., Williamson, G.J., Price, O.F., Ndalila, M.N., Bradstock, R.A., 2021. Australian forests, megafires and the risk of dwindling carbon stocks. Plant Cell and Environment. https://doi.org/10.1111/pce.13916

Burivalova, Z., Butler, R.A., Wilcove, D.S., 2018. Analyzing Google search data to debunk myths about the public's interest in conservation. Frontiers in Ecology and the Environment 16, 509–514. https://doi.org/10.1002/fee.1962

CalFire, 2022. Top 20 Most Destructive California Wildfires [WWW Document]. https://www.fire.ca.gov/media/t1rdhizr/top20_destruction.pdf.

Canadell, J.G., Meyer, C.P. (Mick), Cook, G.D., Dowdy, A., Briggs, P.R., Knauer, J., Pepler, A., Haverd, V., 2021. Multi-decadal increase of forest burned area in Australia is linked to climate change. Nature Communications 12. https://doi.org/10.1038/s41467-021-27225-4

Cebrián, E., Domenech, J., 2022. Is Google Trends a quality data source? Applied Economics Letters. https://doi.org/10.1080/13504851.2021.2023088

Cochrane, M.A., Bowman, D.M.J.S., 2021. Manage fire regimes, not fires. Nature Geoscience 14, 454–457. https://doi.org/10.1038/s41561-021-00775-4

Cottle, S., 2013. ournalists witnessing disaster: From the calculus of death to the injunction tocare. Journalism Studies 14, 232–248.

Doerr, S.H., Santin, C., 2016. The 'wildfire problem': perceptions and realities in a changing world. Philos Trans R Soc Lond B Biol Sci this issue.

dos Reis, M., Graça, P.M.L. de A., Yanai, A.M., Ramos, C.J.P., Fearnside, P.M., 2021. Forest fires and deforestation in the central Amazon: Effects of landscape and climate on spatial and temporal dynamics. Journal of Environmental Management 288. https://doi.org/10.1016/j.jenvman.2021.112310

Douville, H., Raghavan, J., Renwick, R., Allan, P., Arias, M., Barlow R, Cerezo-Mota A, Cherchi TY, Zolina O, 2021. Water Cycle Changes. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1055–1210, doi:10.1017/9781009157896.010.

Fernandez-Anez, N., Krasovskiy, A., Müller, M., Vacik, H., Baetens, J., Hukić, E., Kapovic Solomun, M., Atanassova, I., Glushkova, M., Bogunović, I., Fajković, H., Djuma, H., Boustras, G., Adámek, M., Devetter, M., Hrabalikova, M., Huska, D., Martínez Barroso, P., Vaverková, M.D., Zumr, D., Jõgiste, K., Metslaid, M., Koster, K., Köster, E., Pumpanen, J., Ribeiro-Kumara, C., di Prima, S., Pastor, A., Rumpel, C., Seeger, M., Daliakopoulos, I., Daskalakou, E., Koutroulis, A., Papadopoulou, M.P., Stampoulidis, K., Xanthopoulos, G., Aszalós, R., Balázs, D., Kertész, M., Valkó, O., Finger, D.C., Thorsteinsson, T., Till, J., Bajocco, S., Gelsomino, A., Amodio, A.M., Novara, A., Salvati, L., Telesca, L., Ursino, N., Jansons, A., Kitenberga, M., Stivrins, N., Brazaitis, G., Marozas, V., Cojocaru, O., Gumeniuc, I., Sfecla, V., Imeson, A., Veraverbeke, S., Mikalsen, R.F., Koda, E., Osinski, P., Castro, A.C.M., Nunes, J.P., Oom, D., Vieira, D., Rusu, T., Bojović, S., Djordjevic, D., Popovic, Z., Protic, M., Sakan, S., Glasa, J., Kacikova, D., Lichner, L., Majlingova, A., Vido, J., Ferk, M., Tičar, J., Zorn, M., Zupanc, V., Hinojosa, M.B., Knicker, H., Lucas-Borja, M.E., Pausas, J., Prat-Guitart, N., Ubeda, X., Vilar, L., Destouni, G., Ghajarnia, N., Kalantari, Z., Seifollahi-Aghmiuni, S., Dindaroglu, T., Yakupoglu, T., Smith, T., Doerr, S., Cerda, A., 2021. Current Wildland Fire Patterns and Challenges in Europe: A Synthesis of National Perspectives. Air, Soil and Water Research. https://doi.org/10.1177/11786221211028185

Ficetola, G.F., 2013. Is interest toward the environment really declining? The complexity of analysing trends using internet search data. Biodiversity and Conservation 22, 2983–2988. https://doi.org/10.1007/s10531-013-0552-y

Fukano, Y., Soga, M., 2019. Spatio-temporal dynamics and drivers of public interest in invasive alien species. Biological Invasions 21, 3521–3532. https://doi.org/10.1007/s10530

Ghasemi, B., Kyle, G.T., Absher, J.D., 2020. An examination of the social-psychological drivers of homeowner wildfire mitigation. Journal of Environmental Psychology 70. https://doi.org/10.1016/j.jenvp.2020.101442

Habibi, H., Feld, J., 2018. Do People Pay More Attention to Earthquakes in Western Countries? Universitat Politecnica de Valencia. https://doi.org/10.4995/carma2018.2018.8315

Hopke, J.E., 2020. Connecting Extreme Heat Events to Climate Change: Media Coverage of Heat Waves and Wildfires. Environmental Communication 14, 492–508. https://doi.org/10.1080/17524032.2019.1687537

Houser, C., Vlodarchyk, B., Wernette, P., 2019. Short communication: public interest in rip currents relative to other natural hazards: evidence from Google search data. Natural Hazards 97, 1395–1405. https://doi.org/10.1007/s11069-019-03696-z

Iglesias, V., Balch, J.K., Travis, W.R., 2022. U.S. fires became larger, more frequent, and more widespread in the 2000s, Sci. Adv.

Jones, M.W., Abatzoglou, J.T., Veraverbeke, S., Andela, N., Lasslop, G., Forkel, M., Smith, A.J.P., Burton, C., Betts, R.A., van der Werf, G.R., Sitch, S., Canadell, J.G., Santín, C., Kolden, C., Doerr, S.H., le Quéré, C., 2022. Global and regional trends and drivers of fire under climate change. Reviews of Geophysics In press.

Kam, J., Park, J., Shao, W., Song, J., Kim, J., Gizzi, F.T., Porrini, D., Suh, Y.J., 2021. Data-driven modeling reveals the Western dominance of global public interest in earthquakes. Humanities and Social Sciences Communications 8. https://doi.org/10.1057/s41599-021-00914-7

Kim, S., Shao, W., Kam, J., 2019. Spatiotemporal patterns of US drought awareness. Palgrave Communications 5. https://doi.org/10.1057/s41599-019-0317-7

Kirchmeier-Young, M.C., Gillett, N.P., Zwiers, F.W., Cannon, A.J., Anslow, F.S., 2019. Attribution of the Influence of Human-Induced Climate Change on an Extreme Fire Season. Earth's Future 7, 2–10. https://doi.org/10.1029/2018EF001050

Kouassi, J.L., Wandan, N., Mbow, C., 2022. Exploring Wildfire Occurrence: Local Farmers' Perceptions and Adaptation Strategies in Central Côte d'Ivoire, West Africa. Journal of Sustainable Forestry 41, 173–192. https://doi.org/10.1080/10549811.2020.1845744

Kovalenko, K.E., Pelicice, F.M., Kats, L.B., Kotta, J., Thomaz, S.M., 2021. Aquatic invasive species: introduction to the Special Issue and dynamics of public interest. Hydrobiologia. https://doi.org/10.1007/s10750-021-04585-y

Lagouvardos, K., Kotroni, V., Giannaros, T.M., Dafis, S., 2019. Meteorological conditions conducive to the rapid spread of the deadly wildfire in eastern attica, Greece. Bull Am Meteorol Soc 100, 2137–2145. https://doi.org/10.1175/BAMS-D-18-0231.1

Larsen, L.N.D., Howe, P.D., Brunson, M., Yocom, L., McAvoy, D., Helen Berry, E., Smith, J.W., 2021. Risk perceptions and mitigation behaviors of residents following a near-miss wildfire. Landscape and Urban Planning 207. https://doi.org/10.1016/j.landurbplan.2020.104005

Lidskog, R., Johansson, J., Sjödin, D., 2019. Wildfires, responsibility and trust: public understanding of Sweden's largest wildfire. Scandinavian Journal of Forest Research 34, 319–328. https://doi.org/10.1080/02827581.2019.1598483

McCallum, M.L., Bury, G.W., 2014. Public interest in the environment is falling: A response to Ficetola (2013). Biodiversity and Conservation 23, 1057–1062. https://doi.org/10.1007/s10531-014-0640-7

Mccallum, M.L., Bury, G.W., 2013. Google search patterns suggest declining interest in the environment. Biodiversity and Conservation 22, 1355–1367. https://doi.org/10.1007/s10531-013-0476-6

Mellon, J., 2014. Internet Search Data and Issue Salience: The Properties of Google Trends as a Measure of Issue Salience. Journal of Elections, Public Opinion & Parties 24, 45–72.

Mimura, N., Yasuhara, K., Kawagoe, S., Yokoki, H., Kazama, S., 2011. Damage from the Great East Japan Earthquake and Tsunami - A quick report. Mitigation and Adaptation Strategies for Global Change 16, 803–818. https://doi.org/10.1007/s11027-011-9297-7

Moeller, S.D., 2006. "Regarding the pain of others": Media, bias and the coverage of international disasters. Journal of International Affairs 59, 173–196.

Mondino, E., di Baldassarre, G., Mård, J., Ridolfi, E., Rusca, M., 2020. Public perceptions of multiple risks during the COVID-19 pandemic in Italy and Sweden. Scientific Data 7. https://doi.org/10.1038/s41597-020-00778-7

Moore, P.F., 2019. Global Wildland Fire Management Research Needs. Current Forestry Reports. https://doi.org/10.1007/s40725-019-00099-y

Moritz, M. a, Batllori, E., Bradstock, R. a, Gill, a M., Handmer, J., Hessburg, P.F., Leonard, J., Mccaffrey, S., Odion, D.C., Schoennagel, T., Syphard, A.D., 2014. Learning to coexist with wildfire. Nature 515, 58–66. https://doi.org/10.1038/nature13946

Moustakas, A., 2021. Internet search effort on Covid-19 and the underlying public interventions and epidemiological status. https://doi.org/10.21203/rs.3.rs-583289/v1.

Moustakas, A., Evans, M.R., 2016. Regional and temporal characteristics of bovine tuberculosis of cattle in Great Britain. Stochastic Environmental Research and Risk Assessment 30, 989–1003. https://doi.org/10.1007/s00477-015-1140-3

Munich Re, 2018. The natural disasters of 2018 in figures | Munich Re Topics Online. https://www.munichre.com/topics-online/en/climate-change-and-natural-disasters/natural-disasters/the-natural-disasters-of-2018-in-figures.html.

NOAA, 2018. Costliest U.S. tropical cyclones tables update. United States National Hurricane Center. https://www.nhc.noaa.gov/news/UpdatedCostliest.pdf.

North, B.M.P., Stephens, S.L., Collins, B.M., Agee, J.K., Aplet, G., Franklin, J.F., Fulé, P.Z., 2015. Reform forest fire management. Science (1979) 349, 1280–1281.

Oehl, B., Schaffer, L.M., Bernauer, T., 2017. How to measure public demand for policies when there is no appropriate survey data? Journal of Public Policy 37, 173–204. https://doi.org/10.1017/S0143814X16000155

Palaiologou, P., Kalabokidis, K., Troumbis, A., Day, M.A., Nielsen-Pincus, M., Ager, A.A., 2021. Socio-ecological perceptions of wildfire management and effects in Greece. Fire 4. https://doi.org/10.3390/fire4020018

Pew Research Center, 2019. Smartphone Ownership Is Growing Rapidly Around the World, but Not Always Equally. https://www.pewresearch.org/global/2019/02/05/digital-connectivity-growing-rapidly-in-emerging-economies/.

Pissolito, C., Rossi, S.D., Franzese, J., Raffaele, E., Fernández, M.E., 2020. Modified landscapes: visitor's perceptions of conservation in a natural reserve invaded by exotic conifers. Journal of Environmental Planning and Management 63, 2646–2662. https://doi.org/10.1080/09640568.2020.1742676

Proulx, R., Massicotte, P., Pépino, M., 2014. Googling Trends in Conservation Biology. Conservation Biology 28, 44–51. https://doi.org/10.1111/cobi.12131

Radeloff, V.C., Helmers, D.P., Anu Kramer, H., Mockrin, M.H., Alexandre, P.M., Bar-Massada, A., Butsic, V., Hawbaker, T.J., Martinuzzi, S., Syphard, A.D., Stewart, S.I., 2018. Rapid growth of the US wildland-urban interface raises wildfire risk. Proc Natl Acad Sci U S A 115, 3314–3319. https://doi.org/10.1073/pnas.1718850115

Rosenthal, A., Stover, E., Haar, R.J., 2021. Health and social impacts of California wildfires and the deficiencies in current recovery resources: An exploratory qualitative study of systems-level issues. PLoS ONE 16. https://doi.org/10.1371/journal.pone.0248617

Sahar, O., Leone, V., Limani, H., Rabia, N., Meddour, R., 2018. Wildfire risk and its perception in Kabylia (Algeria). IForest 11, 367–373. https://doi.org/10.3832/ifor2546-011

San-Miguel-Ayanz, J., Durrant, T., Boca, R., Maianti, P., Liberta, G., Artes Vivancos, T., Jacome Felix Oom, D., Branco, A., de Rigo, D., Nuijten, D., 2022. Advance report on wildfires in Europe, Middle East and North Africa 2021, EUR 31028 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-49633-5, doi:10.2760/039729, JRC128678.

Scott, A.J., Knott, M., 1974. A cluster analysis method for grouping means in the analysis of variance. Biometrics 30, 507–512.

Silva, N.T.C. da, Fra.Paleo, U., Ferreira Neto, J.A., 2019. Conflicting Discourses on Wildfire Risk and the Role of Local Media in the Amazonian and Temperate Forests. International Journal of Disaster Risk Science 10, 529–543. https://doi.org/10.1007/s13753-019-00243-z

Silveira, M.V.F., Petri, C.A., Broggio, I.S., Chagas, G.O., Macul, M.S., Leite, C.C.S.S., Ferrari, E.M.M., Amim, C.G.V., Freitas, A.L.R., Motta, A.Z.V., Carvalho, L.M.E., Silva Junior, C.H.L., Anderson, L.O., Aragão, L.E.O.C., 2020. Drivers of fire anomalies in the Brazilian Amazon: Lessons learned from the 2019 fire crisis. Land (Basel) 9, 1–24. https://doi.org/10.3390/land9120516

Smit, I.P.J., Joubert, M., Smith, K., van Wilgen, N., Strydom, T., Baard, J., Herbst, M., 2022. Fire as friend or foe: the role of scientists in balancing media coverage of fires in National Parks. African Journal of Range and Forage Science 39, 136–147. https://doi.org/10.2989/10220119.2021.1991473

Son, R., Kim, H., Wang, S.Y., Jeong, J.H., Woo, S.H., Jeong, J.Y., Lee, B.D., Kim, S.H., LaPlante, M., Kwon, C.G., Yoon, J.H., 2021. Changes in fire weather climatology under 1.5 ◦C and 2.0 ◦C warming. Environmental Research Letters 16. https://doi.org/10.1088/1748-9326/abe675

Tedim, F., McCaffrey, S., Leone, V., Delogu, G., Castelnou, M., McGee, T., Aranha, J., 2020. What can we do differently about the extreme wildfire problem: An overview, in: Tedim, F., Leone, V., McGee, T. (Eds.), Extreme Wildfire Events and Disasters Root. Causes and New Management Strategies. pp. 233–263.

The World Bank, 2020. https://data.worldbank.org/indicator/IT.NET.USER.ZS?end=2020&start=1960&view=chart [WWW Document].

Troumbis, A.Y., 2021. Imbalances in attitudes of European citizens towards biodiversity: Did the communication of the European Biodiversity Strategy work? Journal for Nature Conservation 63. https://doi.org/10.1016/j.jnc.2021.126041

Turki, H., Hadj Taieb, M.A., ben Aouicha, M., Abraham, A., 2020. Nature or Science: what Google Trends says. Scientometrics 124, 1367–1385. https://doi.org/10.1007/s11192-020-03511-8

Tymstra, C., Stocks, B.J., Cai, X., Flannigan, M.D., 2020. Wildfire management in Canada: Review, challenges and opportunities. Progress in Disaster Science 5. https://doi.org/10.1016/j.pdisas.2019.100045

United Nations Environment Programme, 2022. Spreading like Wildfire – The Rising Threat of Extraordinary Landscape Fires. A UNEP Rapid Response Assessment. Nairobi.

Voronova, O.S., Zima, A.L., Kladov, V.L., Cherepanova, E. v., 2020. Anomalous Wildfires in Siberia in Summer 2019. Izvestiya - Atmospheric and Ocean Physics 56, 1042–1052. https://doi.org/10.1134/S000143382009025X

Vosen, S., Schmidt A, 2011. Forecasting private consumption: survey-based indicators vs Google trends. Journal of Forecast 30, 565–578.

West, M., 1997. Time series decomposition. Biometrika 84, 489-494.

Witze, A., 2020. Witze2020_ArticFire2020_Nature. Nature 585, 336–337.