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Media trends and public interest in wildfires in Tuscany, Italy

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Abstract

Wildfires have increased in intensity and frequency since the beginning of the 20th century, primarily driven by climatic and socio-economic changes. This shift makes fire suppression an inefficient approach, warranting further investigation into the human component of forest fire prevention. The analysis of social and environmental factors could be useful in assessing wildfire risks. In this study, we assess communication trends by analysing media news and posts about wildfires in Italy, with a specific focus on the Tuscany region. The paper investigates the relationship between wildfires and media habits in specific areas. The communication analysis results reveal that the year 2017 marked the highest peak of fire news in Italy on Twitter [current name: X] (450). Compared with others, Tuscany is the Italian region with the highest number of reports in the studied period (233 over 10 years). Wildfire-related news spread throughout the year, peaking in the dry season (between May and October, and especially from June to August). Statistical analyses, including single-variable, combination, and interaction models, indicate the strongest correlation between newspapers' chronic articles and the number of wildfire events. The wildfire vs. communication index facilitates the comparison of ecological and social parameters, determining critical areas (CA) in Tuscany. This study highlights the link between media habits and wildfire occurrence as a novel lens for understanding risk perception. Though based in Tuscany, the findings and the index approach offer a transferable method for identifying awareness gaps in fire-prone areas, especially Mediterranean-type regions.

KEYWORDS
media habits, social media analysis, social-ecological study, stimulus-organism-response model, Tuscany, wildfire risk perception

1 | INTRODUCTION

Since the industrial revolution, wildfire behaviour and fire regimes have changed (Brotons et al., 2013; Duguy et al., 2013; Moreira et al., 2020), due to climate alterations and modern socio-economic transformations (Pechony & Shindell, 2010; Pyne & Goldammer, 1997). As a result, wildfires have become more extensive, more intense, and faster moving in the Mediterranean region (Mansoor et al., 2022; Pausas & Keeley, 2021; Ruffault et al., 2018). In addition, winter fire seasons have also become more common, because rainy days are rarer, winds are stronger, and slopes are steeper (Bajocco et al., 2020; Rodrigues et al., 2019; Tonini et al., 2020; Trucchia et al., 2022). Several countries have experienced simultaneous large fires within a single region (Moreira et al., 2011; Tedim et al., 2018), even in traditionally non-fire-prone areas. Climate change has led to more extreme wildfires (Tedim et al., 2018) that are more geographically and temporally widespread. These trends have led researchers and land managers to focus on the "wildfire paradox" (Pyne, 2007) or the firefighting trap. This new paradigm suggests that fire management should shift away from a sole focus on fire exclusion and suppression (Arévalo & Naranjo-Cigala, 2018; Bovio et al., 2017; Calkin et al., 2013; Otero & Nielsen, 2017; Power et al., 2018), and instead prioritise prevention, mitigation, and adaptation strategies (Duguy et al., 2013; Fernandes et al., 2020; Pais et al., 2023; Spadoni et al., 2023), within a broader social-ecological framework (Kirschner et al., 2024; Leone et al., 2020; Moreira et al., 2020; Muhs et al., 2020; Pyne, 1982; Stoof & Kettridge, 2022; Wunder et al., 2021).

Research has analysed the relationship between the socioeconomic system and the occurrence and extent of natural phenomena in the framework of hazard and risk (Bajocco et al., 2012; Misal et al., 2023; Pausas & Vallejo, 1999; Tedim et al., 2016). However, the specific field of wildfire risk and disaster management has traditionally focused on physical drivers, indicating that an exploration of social components may generate new perspectives and enrich theoretical and practical knowledge in this field (Brenkert-Smith et al., 2013; Hamilton et al., 2019; Kasperson et al., 1988; Uyttewaal et al., 2023; Vigna et al., 2021).

Wildfires are a result of a combined social and ecological process, whose risk is reducible through cross-sectoral strategies (Ascoli et al., 2023; Plana Bach et al., 2015). The social factor of communication—understood not merely as the transmission of information but as a process of constructing shared meaning through language, gestures, and cultural practices—is the primary tool that communities use to interact, organise, and develop. For example, the source and content of information presented in the news strongly affects perceptions of the world and human behaviour (Gordon et al., 2012). The environment, through events such as wildfires or related news, generates stimuli that influence individuals, who then produce responses—such as social media reactions—following the stimulus–organism–response (SOR) model. This model, widely used in mass media research, has also been applied to the context of contemporary social media (Fitriani et al., 2016). This process is self-reinforcing: it shapes people's perceptions which gradually forms media habits, depending on the type of media, the underlying cause, and the frequency of exposure (LaRose, 2010).

Nowadays, more information than ever before is delivered by social media, equal to or even surpassing traditional print, radio, and television sources, especially among younger generations, and often at the expense of content quality (European Parliament, 2023). Information disseminated through media is critical in shaping communities' fire risk perceptions (Jacobson et al., 2001; Nilsson & Enander, 2020). Social media is the primary source of information for many people regarding public policy issues, and environmental problems, such as climate change effects, floods, and wildfires (Acikara et al., 2023; Barnes et al., 2008; Blackwood et al., 2022; Hansen, 2011; Zhao et al., 2011). Among existing platforms, Twitter (social network X since July 2023) is considered the most used and valuable in these contexts (Calkin et al., 2013; Carley et al., 2016; Fauzi, 2023; Power et al., 2018; Sakaki et al., 2011; Yigitcanlar et al., 2021). Nevertheless, analysing online search patterns related to wildfires—particularly during high-risk periods—can help better target awareness campaigns, aligning them with public interest and supporting new mitigation and adaptation policies (Santín et al., 2023).

> **Key insights**
> The study revealed the relationship between media habits and wildfire occurrence as a novel lens for understanding risk perception. The most wildfire-related news in Tuscany was observed in 2018, aligning with significant wildfire events. Two indices (Wildfire Index [WI] and Communication Index [CI]) were developed to identify critical areas where gaps in media habits and wildfire impacts are evident. Newspaper articles strongly correlate with extensive wildfire events, emphasising their role in public awareness. Twitter [X] is necessary but insufficient as an online media platform. While the study is grounded in Tuscany, its findings and index-based approach present a transferable method for detecting awareness gaps in wildfire-prone regions, particularly those with Mediterranean-type climates.

This study focuses on Tuscany, Italy (Figure 1), where wildfire management remains largely emergency-driven, and social-ecological studies are still underdeveloped. Policies primarily emphasise suppression, although some shifts are emerging, mainly through initiatives led by the Tuscan Regional Government and affiliated organisations. Our investigation was developed within the framework of an INTERREG project (more details in the following sections).

This paper addresses the following research questions (RQ):

RQ I: How do the information trends about wildfires, found through classical and social media, vary across time and space?

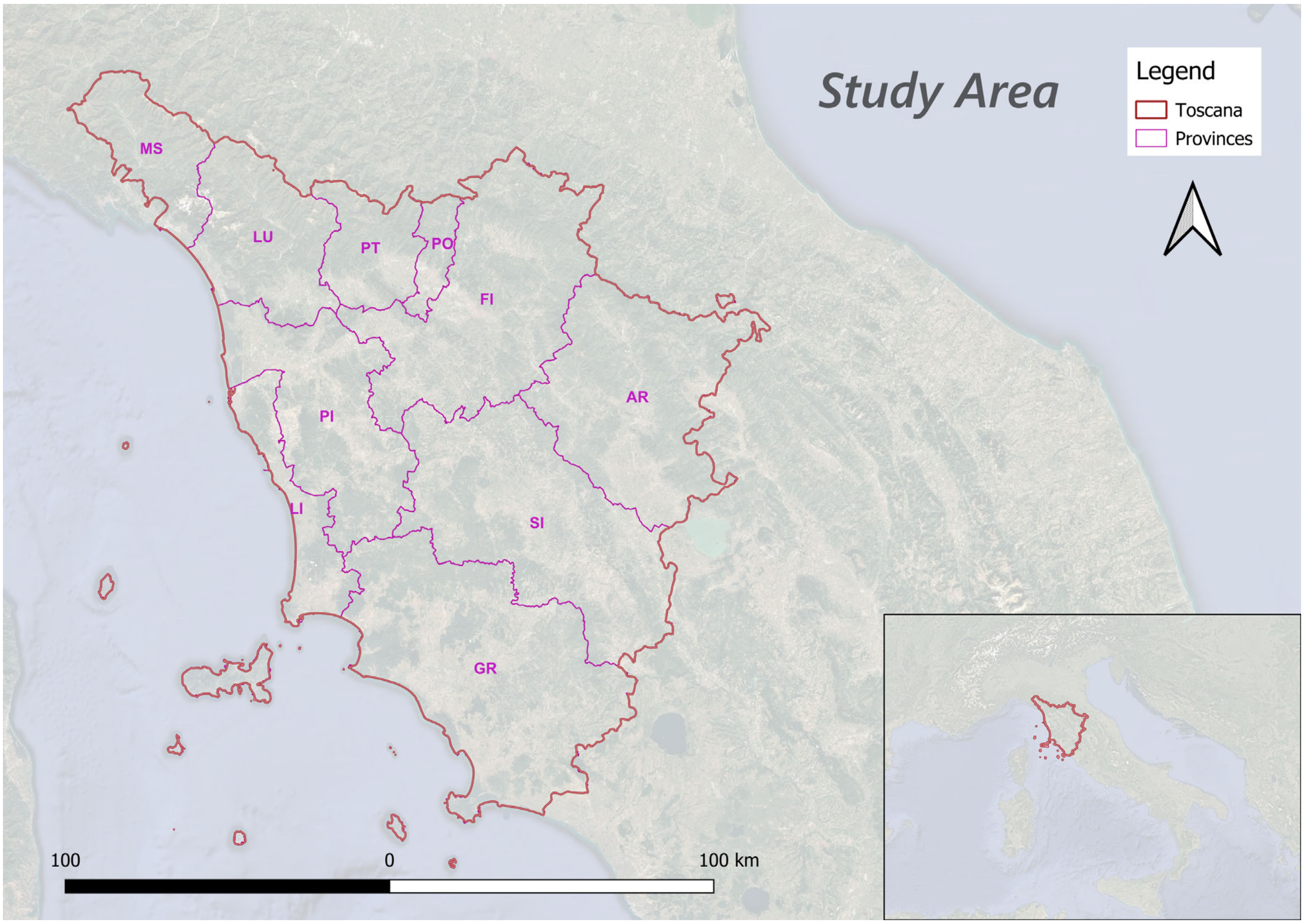

FIGURE 1 Study area: Tuscany region and its provinces.

RQ II: Are media habits and wildfire events related? If so, how?

RQ III: Can mass media—whether printed or digital—serve as a valuable social tool for analysing fire-prone areas and, when combined with wildfire impact data, help identify critical zones?

This research represents an initial step in adopting a social-ecological perspective on wildfire analysis, by incorporating a social parameter—media habits—into the study of wildfire dynamics. Section 2 provides a regional overview, examining key characteristics such as fire frequency and extent across the 10 administrative provinces of Tuscany (Florence, Arezzo, Grosseto, Livorno, Lucca, Massa Carrara, Pisa, Pistoia, Prato, and Siena). The study methodology is also described. Section 3 presents the main findings, identifying critical areas based on the relationship between wildfire impact and communication trends, over 10 years. Section 4 discusses the results and provides a deeper analysis of local perceptions of wildfires, using them as a parameter for risk perception assessment. Finally, the conclusions are summarised in Section 5.

2 | MATERIALS AND METHODS

2.1 | Study area

This study was conducted in Tuscany, one of the largest wooded regions in Italy, covering approximately 1.1 million hectares of total forested area (INFC2015—National Inventory of Forests and Carbon Sinks, 2015). Over the last three decades, the region has experienced an average of more than 500 wildfires per year affecting all provinces, albeit with different weights (Table 1). The presence of tourism facilities (such as campsites, buildings, and beach clubs) and fire-dependent, fire-prone vegetation (for example, the nearby maritime forests of *Pinus pinaster* (Aiton, 1789), and Mediterranean scrub formations) increases the fire risk in terms of ignition probability, spread behaviour, and vulnerability in specific coastland and inland areas of Tuscany.

From a legislative and operational standpoint, the regional government designs, promotes, and adopts fire prevention plans for each at-risk area, aiming for regionally tailored wildfire risk prevention. Gaps and

TABLE 1 Wildfire characteristics considered in the analysis. Number of wildfire events and the burned surface, for each Tuscan province, during the study period 2011–2020 (source: Tuscany Region database).

2011–2020	Number of wildfires	Burned surface
Arezzo	409	391.80
Firenze	573	461.43
Grosseto	373	903.05
Livorno	145	177.88
Lucca	668	2462.74
Massa-Carrara	349	540.96
Pisa	505	2055.50
Pistoia	307	555.75
Prato	82	40.67
Siena	251	872.68

weaknesses in national and supranational legislation on rural management and socio-economic changes over the last century, including urbanisation, abandonment of rural land, and obstacles to management activities such as prescribed fire, have affected wildfire activity in Tuscany (Moreira et al., 2011; Salis et al., 2022).

From 1954 to 1981, the region experienced significant population movement from mountainous and rural areas, which saw a decrease of 132,989 people towards larger cities and the "urbanised countryside". The cities experienced a population increase of 370,354 people, while the "urbanised countryside"—where the industrial district, the typical model of the region, emerged—reached a population of 106,020 (Istituto Regionale per la Programmazione Economica della Toscana - IRPET report, Iommi & Marinari, 2020).

The Italian wildfire governance system is characterised by relaxed laws, a lack of preventative action, and a complex organisational system (Kirschner et al., 2024). In addition, past forest policies in Italy did not work well because of the way institutions and government are organised (Secco et al., 2017). Overall, this has led to an increase in wildfire activity.

2.2 | Data Collection

2.2.1 | Wildfires

Wildfire data were obtained from the Tuscany Region Forest Department database (Regione Toscana, https://www502.regione.toscana.it/geonetwork/srv/api/records/r_toscan:11d9b765-8c47-4c8b-9311-298683aa5800, January 2021) and utilised to develop the indexes and process the final maps used to detect critical areas. The following variables from 2011 to 2020 were selected and classified from the complete archive: burned area and date of each wildfire, wildfire event location (province), and the number of wildfire events per province.

Some information about 2020 wildfire events (such as date, time, place, or burned surface) was missing from the aforementioned database due to the application of legislative decree n.177/2016. This decree suppressed the *Corpo Forestale dello Stato*, delegating its functions to the *Arma dei Carabinieri*, causing the loss of some data about wildfire monitoring and classification during the records transition. Additionally, 2021 was not considered in this study since data were not available at the time. The impact of COVID-19 overwhelmed the system, contributing to the unavailability of data for that year, at least at the time of the present study.

2.2.2 | Media habits

An analysis of communication flows is helpful to study the interaction between social factors and wildfire risk (Brenkert-Smith et al., 2013). In this study, communication was represented by media habits, understood as the amount and type of information on wildfire topics collected from social media and newspapers, from 2011 to 2021. A preliminary analysis enabled a national overview of how much this topic is discussed across the Italian regions.

Twitter was used as the platform, by counting tweets containing selected topical hashtags (see below). For the specific study of Tuscany, two primary sources were considered: Twitter as a social medium and three of the most widely read regional newspapers (QN-La Nazione, Il Corriere Fiorentino, Il Tirreno) (YouTrend, 2022) (https://www.youtrend.it/2022/06/03/la-diffusione-dei-giornali-cartacei-in-italia/, June 2022), as classical media.

Difficulties were encountered in accessing the latter type of sources. A public archive of newspaper articles does not exist, and other local archives lack digital tools essential for keyword research. Several editorial offices that we contacted were unwilling to cooperate. Those who did respond positively requested the signing of a release for the non-public use of the data.

Twitter has been identified in the literature as the most popular social media platform for sharing crisis-related content and information to support decision-making during crises, natural hazards, or disasters (Alam et al., 2018; Comes et al., 2015; de Albuquerque et al., 2015; Karimiziarani et al., 2022). This is particularly true in the North American context, where the majority of studies in this field have been conducted. In European countries, some research has also been conducted using this social network (for example, de Albuquerque et al., 2015).

Facebook was the most used social network in Italy in the studied period (Social Media Stats, 2023) https://gs.statcounter.com/social-media-stats/all/italy/#monthly-201101-202012. However, data from Facebook was not completely available or as accessible as data from Twitter. Thus, Twitter was the only social media platform used in this paper, even though the limitations of using just one platform were considered.

Twitter data was collected through a query containing thematic hashtags (*#incendioboschivo*—forest fire or wildfire in English [the two English terms are often considered synonyms in Italian]; *#antincendiboschivi*—forest firefighting service in English; *#aib* – the Italian acronym for the forest firefighting service; *#rischioincendio*—wildfire risk in English; #wildfire; #forestfire; *#incendio*—fire in English); a chosen period (2011–2021); and specifying the country (IT) and then also the place ("Tuscany"), with the tool 'Packets for academic research purposes' in the R software (R Core Team, 2022). Further analyses were undertaken related to time (study period) and space (place the post referred to), considering the number of tweets and their hashtags' repetition. The latter was considered a more interesting variable to use because of the possibility of reaching a wider audience, the chance to expand the meaning of the message, and, finally, to be consistent with the research methodology, which began by using the seven hashtags as filters.

For regional newspaper analysis, we formally requested all of the published articles, by publication date (2011 to 2021) and with the keyword *incendio boschivo* (forest fire or wildfire in English) from our selected newspaper agencies. Articles were then classified by province, year, newspaper title, three topic categories, and keywords (*AIB* or *antincendio boschivo*—forest firefighting service in English; *rischio incendio boschivo*—wildfire risk in English; and *incendio boschivo*—forest fire or wildfire in English) to standardise the printed and online information. All data were then clustered for quantitative analysis, while newspaper data were also used to develop qualitative analysis (Given, 2008).

2.3 | Data analysis

2.3.1 | Descriptive analysis

Tweets and hashtags referring to Italy were first grouped to establish a general background about the trend of media habits across time and space. Quantitative analysis was conducted at a regional level, and both newspaper (*NP*) and Twitter sources (*TW*) were used to develop a communication map. The number of repetitions of articles and hashtags per year was assigned to the corresponding province and then associated with the coordinates (N, E) of each centroid. Data with no location information except for Tuscany or Italy were considered in the general count but not in the amount for each province.

Descriptive data from newspapers were classified by topic and publication month. A circular distribution was applied (Landler et al., 2018; Mahan, 1991; Marchi et al., 2014), and a radar chart was developed along the 12 months of the year. Newspaper articles were grouped by the main topic using the following criteria:

Chronicle *(CH)*: articles about a specific event.
General Information *(GI)*: articles about best practices, recommendations, laws, and expert opinions.
Interventions *(INT)*: articles referring to wildfire monitoring, post-fire rehabilitation work, training, community engagement in events, and research/educational activities.

Thus, an overview of the monthly distribution of targeted forest fire information, in Tuscany, over 10 years was provided.

2.3.2 | Statistical analysis

To understand the relationship and significance of the regional data, a regression approach was applied using statistical methods with R software (R Core Team, 2022). Linear and non-linear regression analyses (Gareth et al., 2013; Wilkinson & Rogers, 1973) were performed to explain the relationship between media habit and wildfire features (in the manuscript, these are the number of events and the area burned, both classified by month and year) and to estimate the weight of each media. Three types of linear functions were computed to explain the dependent variables and classified by month and year:

- Single variable approach, where the number of wildfire events OR the hectares of the burned area was alternatively used as the independent variable; the results with the highest significance were also plotted for further analysis.
- A two-variable approach combined the number of wildfire events AND the burned areas into one independent variable.
- Interaction between two-variable approach, supposing a more significant effect of the combination of the number of wildfire events WITH the burned areas on media compared with the sum of the individual independent variables.

The wildfire parameters were divided into five classes according to the quartile values of the distribution of the number of wildfires and the average area burned per month, with all zero values separated. Based on the results (see Table 3, Section 3.2), the data were plotted (Figure 6, Section 3.2) using R software (R Core, 2022) to highlight trends. The high variability did not allow precise identification of thresholds, and the data were categorised into two periods, from May to October (circles, dry season) and from November to April (triangles, wet season). The above methodology was used to build a statistical explanatory model to describe how natural forest fire events influence media habits.

2.3.3 | Index development and map processing

The data collected was used to build the following indices: the Wildfire Index (WI) and the Communication Index (CI). One index was developed for each year and province, so the data were previously classified. The CI (Equation 1) was conceived as the media coverage (hashtag repetitions and all newspaper articles) about the occurrence of forest fires: depending on the higher parameter, a negative (events > info) or positive (info > events) trend of the communication is defined. The WI (Equation 2) was designed like the burned surface over the total forested area, to understand how much of the latter was burned. The information about the wooden surface area, referred to as the forested area, was taken from the RAFT (Rapporto sullo stato delle Foreste in Toscana, Regione Toscana & Compagnia delle Foreste, 2020) and from the Regional administration web database (Geoscopio, https://www.regione.toscana.it/-/geoscopio, March 2022), again for each province and year. The final index (Equation 3) was represented by the relation of the previous two: when the relation is positive, media habit presents gaps.

Following data collection, the computational process resulted in two indices:

$$Communicationindex = \frac{hashtagrepeats \wedge newspaperarticles}{numberofwildfireevents} \cdot k$$

$$Wildfireindex = \frac{burnedarea}{woodenarea} \cdot k$$

The equation described the relationship between them:

$$Wildfireindexvs.Communicationindex = \frac{WildfireIndex}{CommunicationIndex} \cdot k$$

*Where k is a coefficient equal to 100, used to maintain the accuracy of the decimal digits.

Each index was normalised (Han et al., 2012) according to the highest value for each year and province, making the indices comparable across time and space. The indexes were then uploaded to QGis to build interactive maps, helpful in identifying gaps and critical geographic areas. The obtained values were classified into five classes for each index, according to the equal counting mode (quantum). The final selection of critical areas also considered other variables and territory characteristics, including the cooperation area (that is, project boundaries) of the Med Star project Interreg maritime IT FR (2019), a brief socio-economic background analysis, the reading of the *PSP* (*Piani Specifici di Prevenzione AIB*, wildfire specific prevention plans in English) introduced by the Regional Law 99/00, and meetings with officers and technicians from Tuscany (D.R.E.A.M., 2019, 2020a, 2020b).

3 | RESULTS

3.1 | Media habit analysis

Table 2 displays the overall results from the data collected from Twitter, regardless of the place of reference or the year of publication.

The first results from the time analysis revealed that, considering the entirety of Italy (Figure 2a), the peak occurred in 2017, expressed by the number of hashtags' repetitions (450 out of 437 tweets) related to wildfires. This observation aligned with the European Commission's European Forest Fire Information System (EFFIS) database, which reported 788 large fires (burned surface > 30 ha) in Italy during 2017—more than five times the average of 142 large fires annually from 2008 to 2016. During that year, this surge placed Italy at the top of the European Union ranking for wildfires. Within Tuscany, the peak of hashtags' repeats about wildfires occurred in 2018 (Figure 2b), coinciding with the Calci Wildfire, which burned 1148 ha and stood as the largest forest

TABLE 2 Quantitative analysis of the collected data from Twitter, tweets, and hashtags.

Tweets number	Timeframe	Retweets number	Replies number	Likes number	Region or country of origin	Location
1310	2011–2021	1492	155	1687	Tuscany or others/Italy	Province, city, village

Hashtags repetitions							
#AIB	#antincendioboschivo	#forestfire	#incendio	#incendioboschivo	#rischioincendio	#wildfire	# total repeats
264	55	25	951	81	6	63	1445

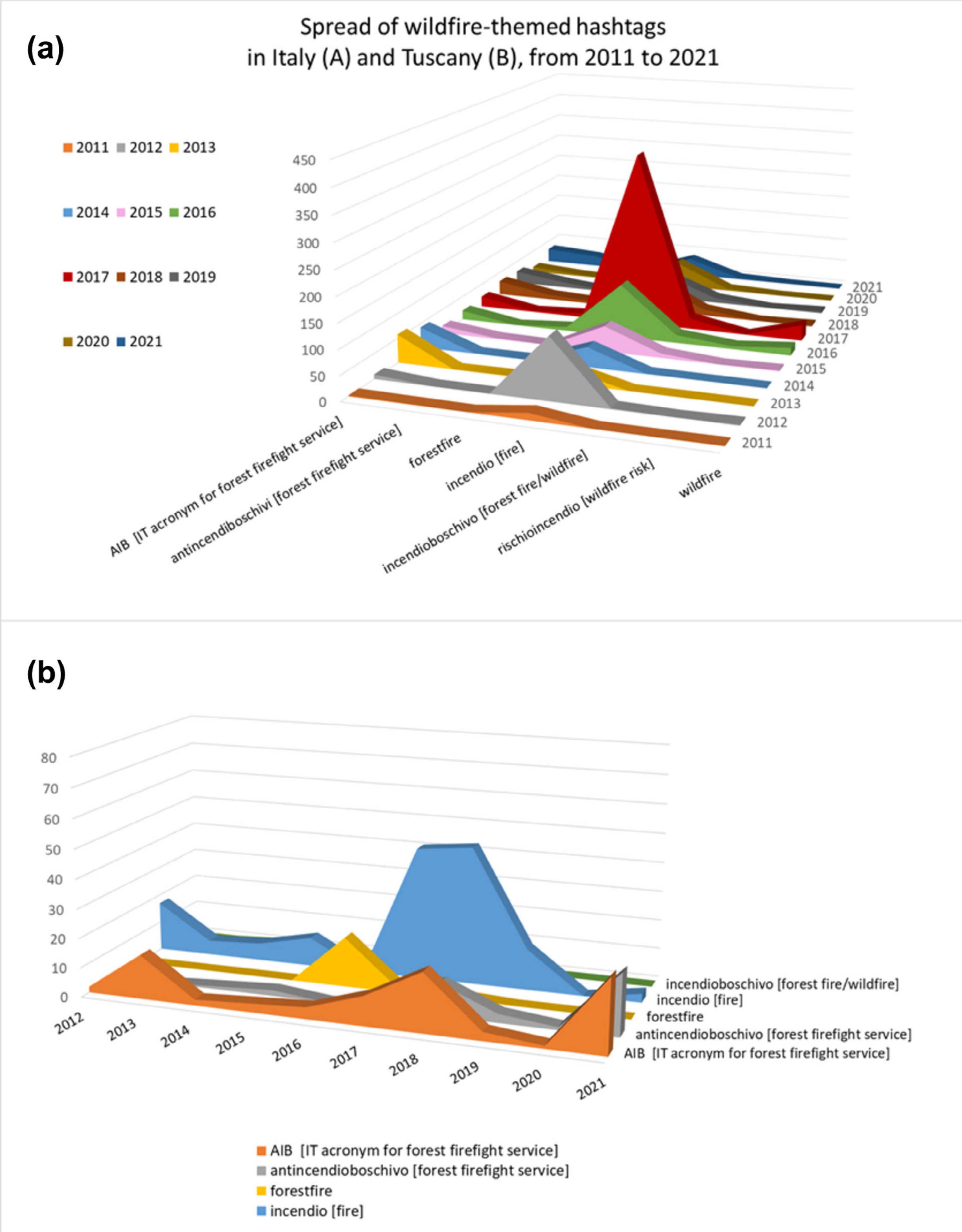

FIGURE 2 Thematic hashtag distribution from 2011 to 2021 from (a) all of Italy and (b) Tuscany only (data source: Twitter).

fire in the 10-year study period. The overall trend in wildfire-related news in Tuscany closely mirrored wildfire behaviour and the most remarkable events documented by the regional database.

Over the 10-year study period, the geographical analysis based on the place the post referred to revealed that Tuscany accounted for the highest number of tweets posted about wildfires (233), totalling

120 only in Pisa province. The following regions were Campania (136), Lombardia (98), Sicilia (87), and Piemonte (82) (Figure 3a,b). As for themed hashtags distribution, the regions with a more significant number of repetitions were Tuscany (294), Campania (139), Lombardia (134), Lazio (98), and Piemonte (90), with #incendio (950) and #AIB (264) as the most spread labelled words (Figure 3c). This finding is consistent with the Italian National Forest Inventory database, which ranked these regions as the top ones for the number of wildfires and burned surface area. Furthermore, Pisa had the highest number of hashtag repetitions (156) followed by the provinces of Florence (39) and Prato (32) (Figure 3d).

The results from a qualitative-quantitative analysis of newspaper articles revealed that the years with the highest number of *NP* articles were 2017 (111 articles) and 2019 (120 articles), out of 721 *NP* items collected.

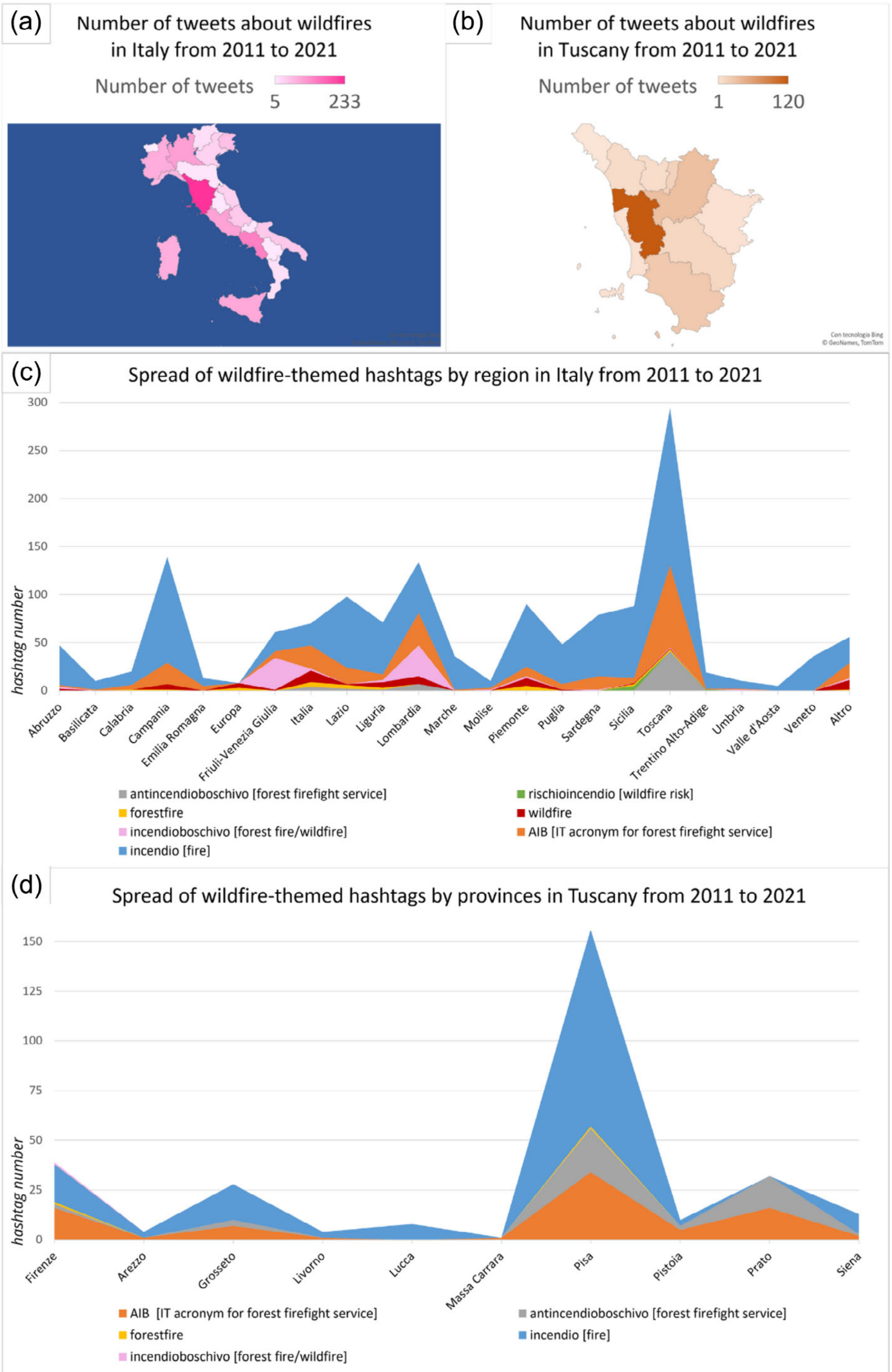

FIGURE 3 Thematic hashtag distribution according to place: the number of tweets collected and geographically tagged by users, in Italy (a) and in Tuscany (b); thematic hashtags with data from all of Italy, divided by region (c), and Tuscany only divided by province (d) (data source: Twitter).

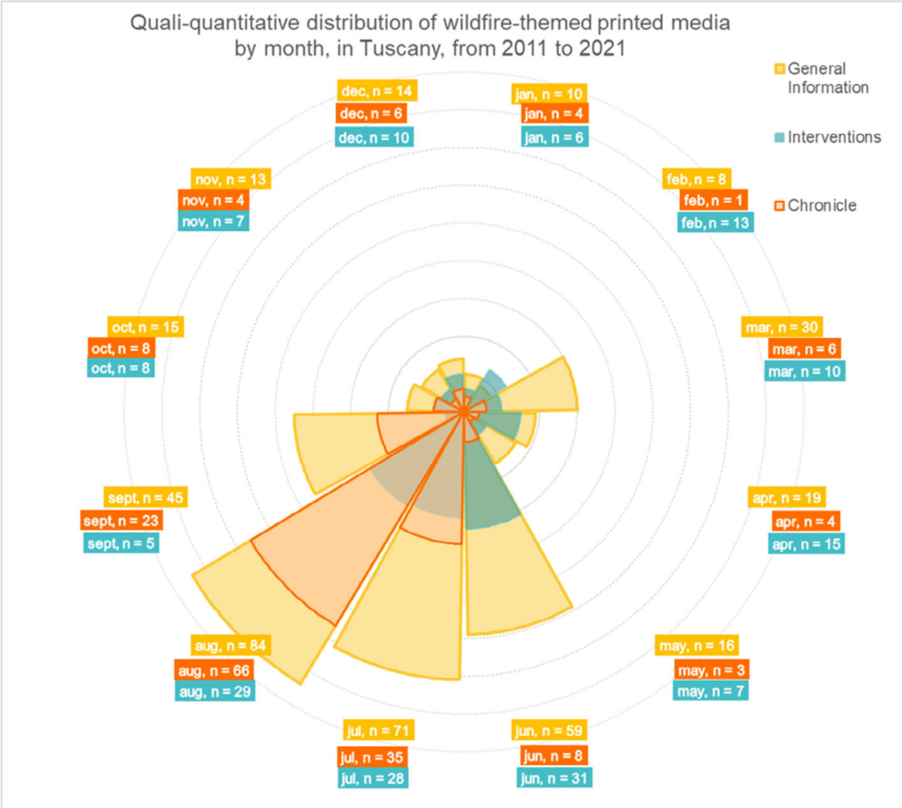

FIGURE 4 Quali-quantitative distribution by month of the newspaper articles classified by type: general information, interventions, and chronicles using Tuscany newspaper data from 2011 to 2021.

TABLE 3 Correlation between wildfire features (source: dataset Tuscany Region, 2022) and media sources (source: Twitter and local newspapers, 2022). TW: Twitter posts, NP: newspaper, CH: chronicle (articles).

Single variable model				
Independent variable	**Dependent variable**	**R^2**	**Adjusted R^2**	***p* value**
Number of wildfire events	All media	0.4466	0.4419	<0.001
	TW	0.2321	0.2255	<0.001
	NP	0.4282	0.4233	<0.001
	CH	**0.6125**	**0.6092**	**<0.001**
Burned area	All media	0.4776	0.4731	<0.001
	TW	**0.5762**	**0.5726**	**<0.001**
	NP	0.2249	0.2183	<0.001
	CH	0.3783	0.3730	<0.001

The most significant volume of *CH* news (168 in total) was concentrated during the dry season, from July to September, aligning with the high-risk period for wildfires. This pattern reflected an expected interest and trend (see Figure 4). *INT* articles (169 in total) were distributed across the year with two peaks in February and April, and another during the summer months, from June to August (see Figure 4). GI articles related to wildfires were the most numerous (384 in total) and frequent, not evenly distributed throughout the year, with a notable increase in March and a peak between June and September (see Figure 4). This may be attributed to the considerable number of burning bans and regulations enacted in rural areas during the high-risk period.

3.2 | Relationship between media habits and wildfires

The multiple linear regression analysis results are summarised in Tables 3 and 4. Only four variables were significant: all media, newspaper articles, tweets, and

TABLE 4 Correlation significance between wildfire codependent variables (source: dataset Tuscany Region, 2022) and media habit parameters (source: Twitter, local newspaper, 2022). TW: Twitter posts, NP: newspaper, CH: chronicle (articles).

Independent variable	Dependent variable	R^2	Adjusted R^2	p value
Combination model				
Number of wildfire events AND Burned area	All media	0.5682	0.5608	<0.001
	TW	0.5733	0.5660	<0.001
	NP	0.4348	0.4251	<0.001
	CH	**0.6377**	**0.6315**	**<0.001**
Interaction model				
Number of wildfire events WITH Burned area	All media	0.4518	0.4472	<0.001
	TW	0.3693	0.3639	<0.001
	NP	0.3158	0.3100	<0.001
	CH	**0.5366**	**0.5327**	**<0.000**

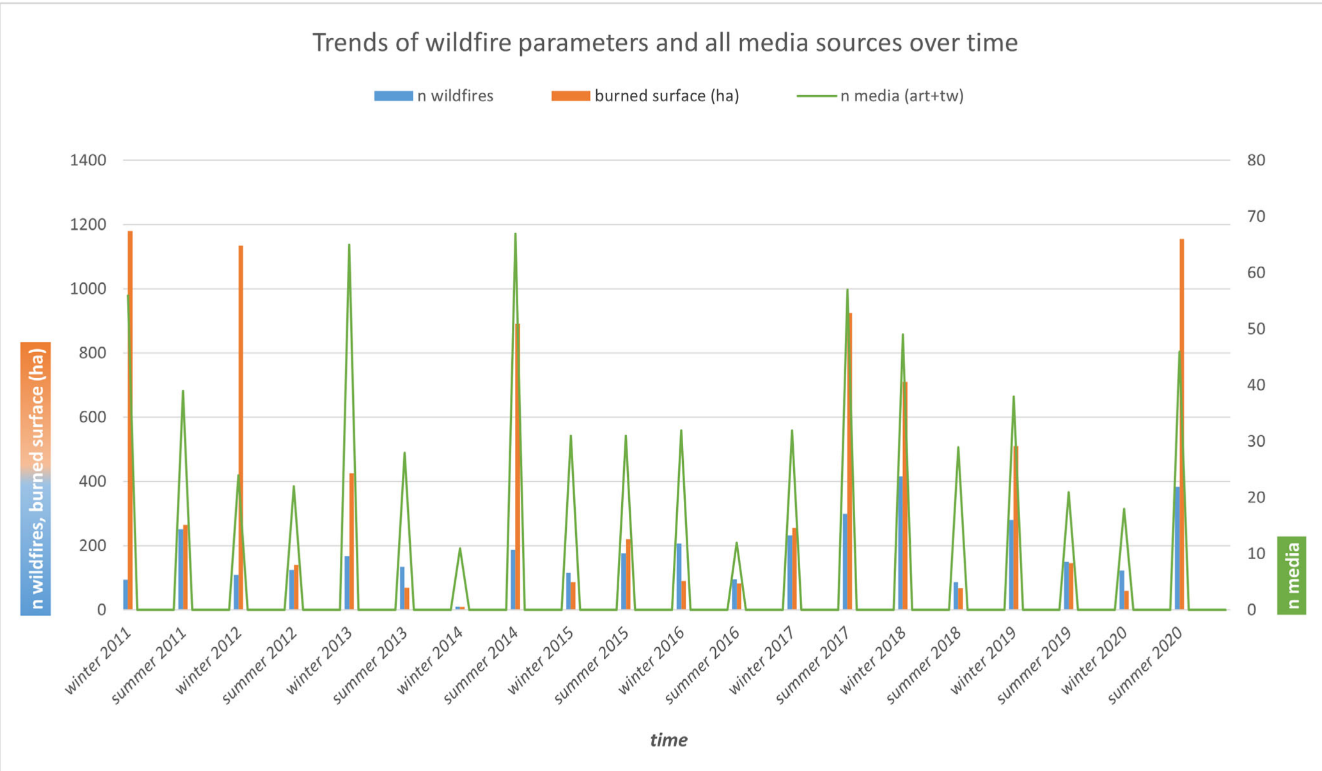

FIGURE 5 Trend of the number of wildfires, burned surface, and all media investigated in Tuscany, Italy, from 2011 to 2020.

chronicle articles. The variables with the highest adjusted R^2 values were considered the most explanatory. In the single-variable model (Table 3), *CH* articles were deemed most relevant to the number of wildfires (adjusted $R^2 \approx 0.6$), while tweets were identified as most pertinent to the burned area (adjusted $R^2 \approx 0.57$). This suggests that these media types were closely related to their respective wildfire parameters. In combination and interaction models, *CH* articles emerged as the most explanatory variable (adjusted $R^2 \approx 0.63$ and 0.53, respectively) (Table 4).

From a general perspective, Figure 5 illustrates trends of media types, the number of wildfires, and burned areas, suggesting a correlation throughout the studied period. The monthly trends from 2011 to 2020 revealed changes, but there was a precise concentration of news in the dry months following the wildfire trend.

We expected that the relationship between all media sources and the number of wildfires would be linear. However, an excellent dispersion in Figure 6a was found in the relation between all media data and the

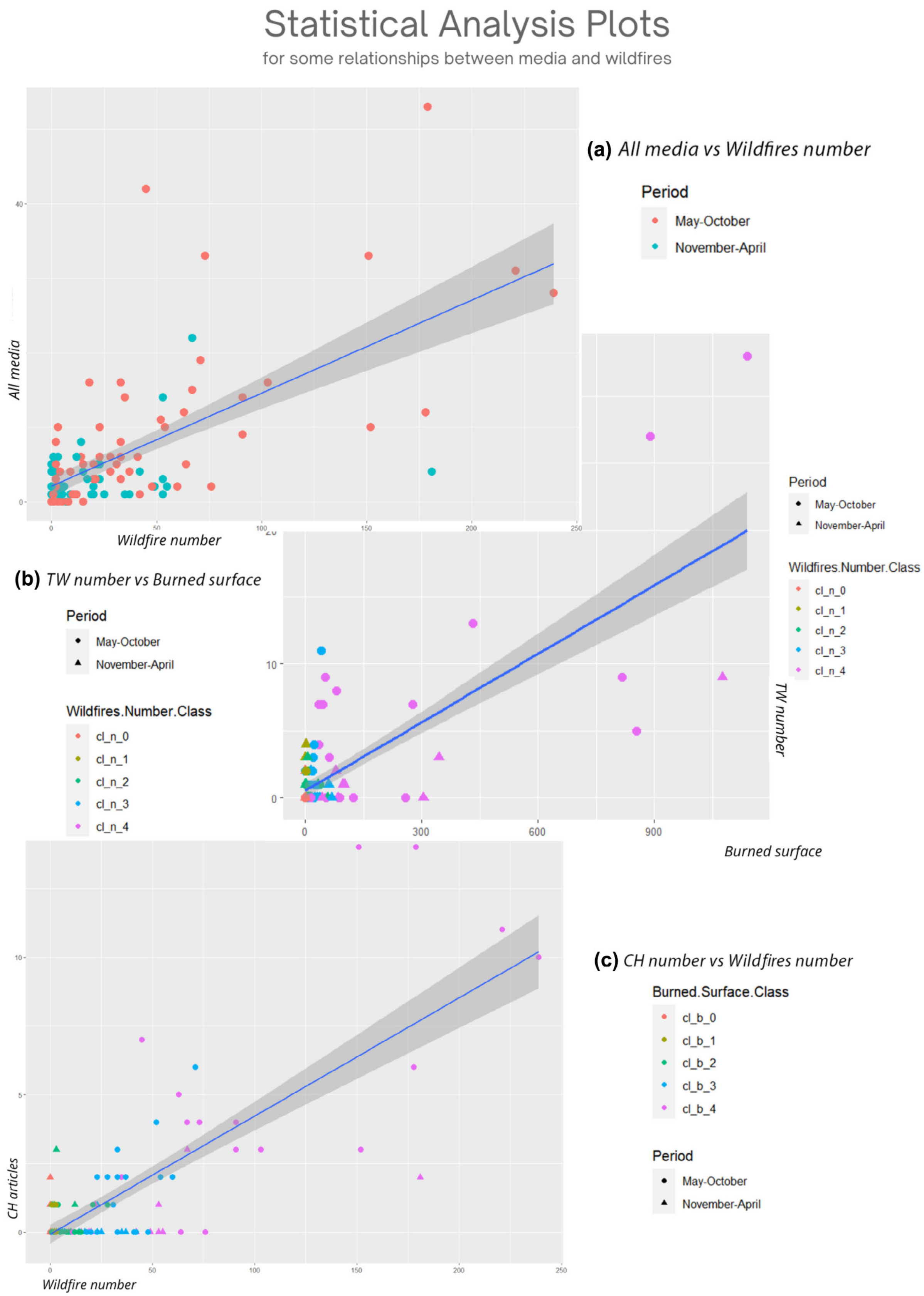

FIGURE 6 Legend on next page.

number of wildfires. Fire events in the dry season were the most numerous and had the widest media coverage. Focusing on the most significant relations (Tables 3 and 4), the one between Twitter posts and burned surface showed a large variability (>x̄) that increased with the burned surface (highest values for the 4th burned surface class, x̄ = 4.867 ha, with = ±7.678 ha; Figure 6b). CH articles were in relevant number for events that occurred from May to October with significant burned surfaces (Figure 6c), although the dispersion was still high (>x̄) and grew with the burned surface (4th burned surface class: x̄ = 3.267 ha, with = ±4.143 ha, the highest value), the trend looked more linear than the first general relation.

3.2.1 | Indexes and maps

The processed maps illustrate changes in wildfire (Figure 7a) and communication trends (Figure 7b) over time, highlighting provinces where burned surfaces are larger, correlating with the number of published media articles. The ratio between WI and CI (Figure 7c) reveals areas where the two factors are unbalanced (critical areas). Florence province exhibited a positive, stable condition, with non-extreme values for WI and CI (WI vs CI range of 0.33 to 13.30). Arezzo showed an oscillating trend in CI with substantial increases in 2016 (61.07) and 2020 (42.17), despite 2013 being a critical year for WI (31.24). Grosseto province was interesting for its strongly oscillating trend (range of 0.12 to 100.00; average of 25.11) and critical situations of 2012–2013 and 2016, due to extremely high WI (range of 44.39 to 56.13). Livorno province did not show a critical situation (average WI vs. CI of 4.02) and only had 3 years of outlier values for WI (2013: 61.21, 2016: 72.37, and 2020: 53.73). Lucca province showed the highest values for WI (range of 7.37 to 100.00, average of 63.74), and the CI highlighted a problematic situation (average of 12.45, the lowest among all provinces). Massa Carrara was a fire-prone area with critical years from 2011 to 2012 (WI = 56.40 and 47.94, respectively), while CI tended to be high, except when it decreased sharply in 2017 (8.50) and 2018 (7.15). Pisa province shows high values for the WI (average of 43.08), while CI increased after the great fire event in 2018 (average of 33.51 before 2018; average of 62.90 after 2018). Many interventions were conducted after that wildfire to protect land, infrastructure, and people. Pistoia province was characterised by a strong WI (range of 7.04 to 100.00, average of 58.72) and low CI (range of 0 to 66.67, average of 20.19). In Prato province, the CI was in the normal range (average of 29.41) while the WI was extremely low (average of 2.21). The last province, Siena, was not a very fire-prone area (average of 15.3), except in 2012, a critical year in terms of both WI (100.00) and CI (25.53).

3.2.2 | Recognition of CA

The map in Figure 8 was developed to highlight areas recognised through specific criteria: results of WI and CI, their ratio, and other features related to the territory mentioned in previous sections. These areas are considered crucial for guiding future studies and prevention measures. The provinces of Lucca, Pisa, and Grosseto are included. Further considerations about this product's selection and forthcoming uses are discussed in the next section.

All the presented data, reported in aggregate forms from subsection '2.2 | Data Collection' until subsection '3.2 | Relationship between media habits and wildfires', are available in their extended form in the 'Supporting Information' Section.

4 | DISCUSSION

This study explores the relationship between media habits and wildfire events, highlighting the role of both traditional and digital media in shaping public awareness. Given the increasing importance of timely and accurate information in wildfire risk management, understanding these dynamics is critical to improving prevention strategies and community engagement. By integrating qualitative and quantitative media analysis, we identify key patterns highlighting the need for ongoing, year-round wildfire communication efforts. The results are discussed deeply in the following subsections.

4.1 | Media habit analysis

Twitter is a valuable tool for analysing awareness trends during or after a wildfire event (Karimiziarani et al., 2022). It is important to note that some data collected on Twitter (about 38% of the total) originated from other sources, including hyperlinks from online

FIGURE 6 Linear function plots with a single variable approach of the relationship between media (all, CH, TW) and wildfires (number and burned surface). (a) Wildfire number by all media; (b) burned surface by tweets number, where wildfire class number (cl_n_x) refers to a classification according to the number of events in ascending order; and (c) wildfire number by chronicle articles, where burned surface class (cl_b_x) refers to a classification of the events according to the area burnt extent, in ascending order. Only the relations that returned an adjusted R^2 > 0.5 (see Table 2) were plotted. Time is divided into two seasonal periods. TW: Twitter posts, CH: chronicle (articles).

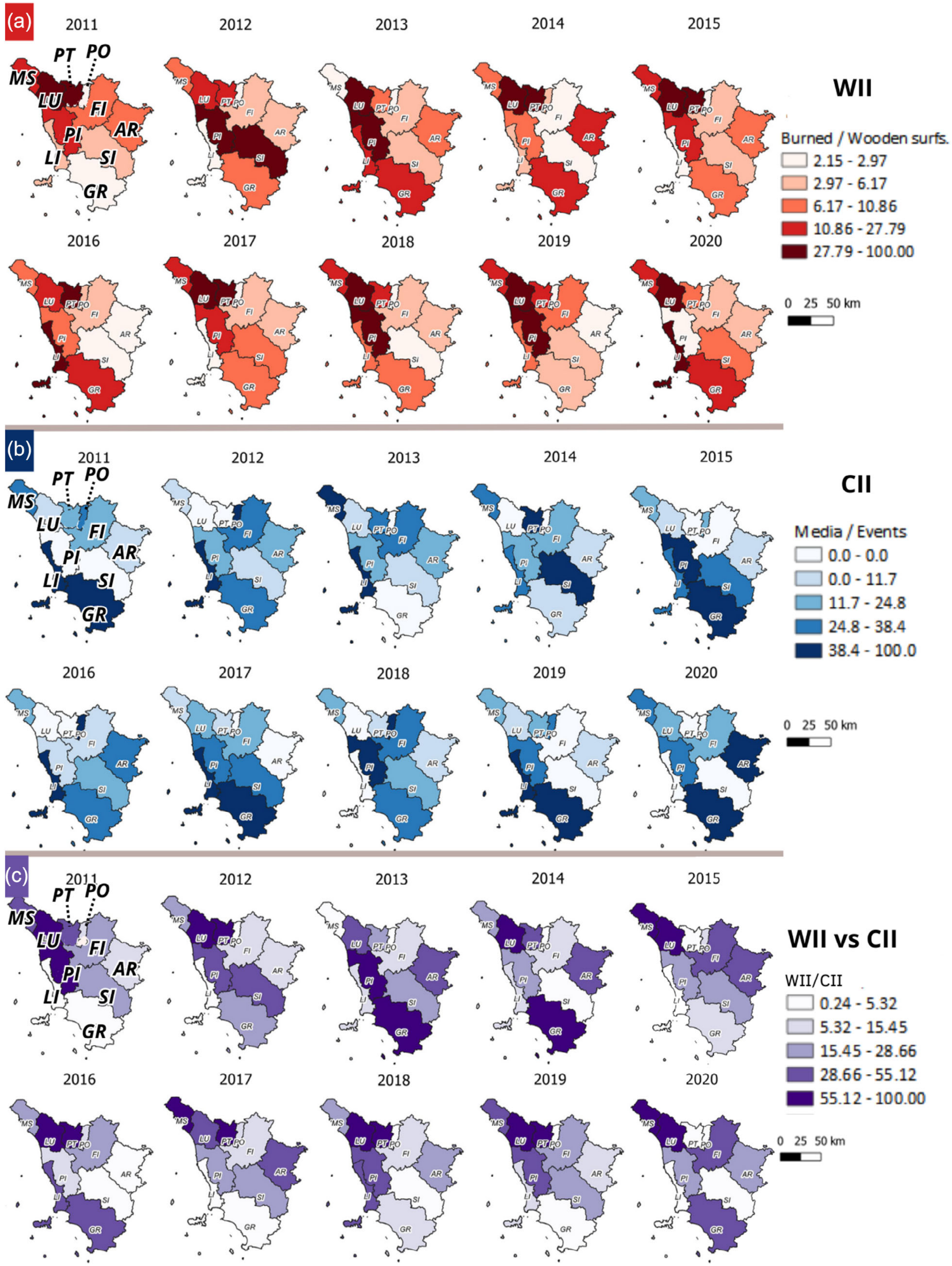

FIGURE 7 Legend on next page.

FIGURE 7 Maps of the evolution of (a) the WI, with values ranging from 0 (white; narrow burns) to 100 (darker red; wider burns); surfs. means surfaces; (b) the CI, with values ranging from 0 (white; media near to 0) to 100 (darker blue; full coverage); and (c) the ratio between the WI and CI, with values ranging from 0 (white) to 100 (darker violet), highlighting the CA. A greater intensity of colour corresponds to the most CA, where the ratio reveals an imbalance. Labels code for the province: AR = Arezzo; FI = Firenze; GR = Grosseto; LI = Livorno; LU = Lucca; MS = Massa Carrara; PI = Pisa; PO = Prato; PT = Pistoia; SI = Siena.

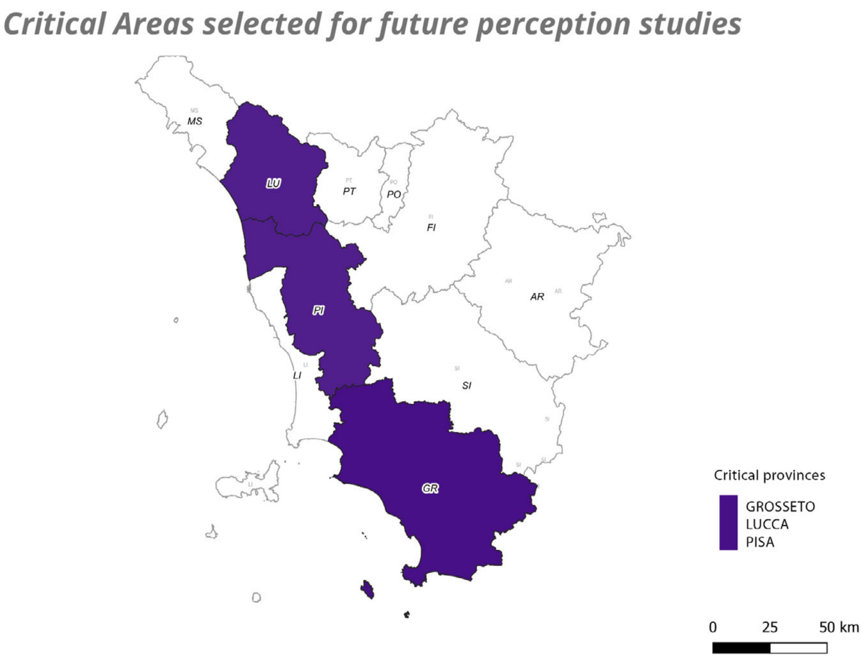

FIGURE 8 The selected provinces of interest, chosen using an integrated approach based on the developed maps and other considerations (cooperation area of the Med-Star project Interreg IT FR, a socio-economic background analysis, PSP—wildfire specific prevention plans, in English—consulting, and meetings with officers and technicians from Tuscany).

newspapers, Instagram, Facebook, other social networks, and competent bodies' websites. This allowed us to fill the gap caused by the less frequent use of Twitter in Italy than in other countries (for example, the United States, Canada, or Australia). The trend observed in collected tweets and hashtag repetitions aligns with the number of wildfires, especially considering the time; the two factors are consistent. However, some mismatches arose in spatial analysis due to the different uses and spread of the communication tool considered for this study. For instance, Tuscany is not at the top rank for wildfire frequency and intensity among Italian regions, despite the results from Twitter suggesting otherwise. Findings show that this region's frequency of wildfire-themed hashtags was the highest—nevertheless, the regions following Tuscany in these media habits aligned with wildfire occurrence in those areas. In summary, tweets and hashtags serve as a reliable tool for comprehending wildfire general trends on a broader scale. However, their reliability may diminish when zooming in on specific situations, where other parameters (for example, the spread of use of social networks) should be taken into account. The study also focused on Tuscany because of the high frequency of reports on forest fires.

Qualitative-quantitative analysis of printed media revealed a two-phase trend throughout the year. The wildfire issue is predominantly discussed during the high-risk period (especially from June to August), with *CH* articles about specific events notably published during that time. Although *GI* and *INT* articles are also primarily published during the summer season, they exhibit consistency in some winter months as well. This boost, observed from March to April, aligns with a new wildfire winter period, especially in the Mediterranean area (Ager et al., 2014; Moreira et al., 2020; Rodrigues et al., 2019; Salis et al., 2014; Tonini et al., 2020; Trucchia et al., 2022). Therefore, the slight debate on the topic in this period leads to the necessity for an increase in public awareness through preventive measures, post-fire interventions, and general information about best practices and behaviour to address the wildfire risk. The type of information gathered was heterogeneous, reflecting seasonal differences in both wildfire occurrences and prevention activities. Future studies may benefit from increasing the number and sources of *NP* articles, as well as diversifying media types to include other platforms such as social networks, Telegram channels, YouTube, Google Trends, broadcasts, television programmes, and radio programmes.

Additionally, expanding the geographic scope to analyse local, regional, and national levels, as suggested in other studies (Karimiziarani, 2023; Walker et al., 2020), could provide a more comprehensive understanding of wildfire media habit dynamics.

4.2 | Relationship between media habits and wildfires

When considered in isolation, any media source exhibits limitations in communication analysis, underscoring the importance of incorporating various sources in this study. For instance, traditional newspapers (particularly *CH*) face constraints in directing public attention, typically covering only larger wildfire events and publishing daily. On the other hand, online media provide real-time updates and are accessible to anyone with an internet connection, resulting in increased data volume and distribution across time and space. Despite the burned surface, *Twitter's* posts showed a stronger correlation with the 4th Wildfire Class Number (Figure 6b), confirming the quantitative linear relationship between this media type and wildfire occurrences.

From a qualitative standpoint, Twitter lacks a filter to avoid 'false friends' (tweets discussing a different wildfire event than the one of interest), and relational analysis with wildfires is limited to comparing the number of hashtags with the number of forest fire events ($\gg\bar{x}$). The coefficients and values obtained effectively explain the primary relationship, evident in the matching peaks and trends in media habit and wildfire data (Figure 5). This enables us to define the relationship between media habits and wildfires and address the main goal of the paper and answer *RQ* II positively. In summary, media habit is linked to wildfire events, larger and greater in number, or to a specific fire season (in this study, May–October). This disparity in terms of interest needs to be overcome, since implementing wildfire mitigation policies requires a year-round approach. The public, indeed, is a key driver for the decision-making process. (Santín et al., 2023).

4.2.1 | Indexes and maps

A brief literature review revealed other similar indices or charts, such as the Hazard Risk Awareness (*HRA*) index (Karimiziarani et al., 2022) and the Wildfire Risk Maps (Vigna et al., 2021). While the *HRA* index considers meteorological and demographic parameters, it only provides static data. Vigna's mapping methodology includes community involvement, introducing a participatory element to vulnerability and hazard concepts for risk definition. The index proposed in this work, comparing wildfire parameters and media habits, lays the foundation for a deeper investigation, mostly based on risk perception and community engagement. Future research will explain the results, which shall enrich the one described here. However, this index helps determine places to pay more attention to in terms of media habits and stands among the few describing natural disturbances by juxtaposing physical and social parameters. Wakefield et al. (2005) argue that the reporting of an event "diagnoses, evaluates, and prescribes solutions to social problems," just as media habit was used in this study to face the wildfire problem, following a stimulus-organism-response model.

Nevertheless, the maps are a valuable tool to facilitate the understanding of a process and its dynamics, in this case the relation between media habits and wildfire occurrence. It is a replicable instrument, regardless of the geographical location and the type of natural disturbance. This kind of investigation should not be taken for granted in the context of the study: indeed, in the Mediterranean basin, an index like the one here developed represents a novelty, as well as a participatory approach to the wildfire issue.

At the regional level, the areas with worse relations, as explained by the indexes, include the provinces of Massa-Carrara, Lucca, Pisa, Grosseto, and Pistoia. These areas warrant further analysis of risk perception (Jacobson et al., 2001; Nilsson & Enander, 2020; Shoemaker & Vos, 2009). Due to the complex dynamics and oscillating trends over the years, Grosseto was selected as an interesting case study based on the WI vs. CI. The highest WI value among all provinces led us to consider Lucca province for the subsequent analysis of CA. Pisa province, adjacent to Lucca and linked by the Monte Pisano massif, has a historical fire susceptibility. Following the Calci Wildfire in 2018, numerous interventions were implemented to protect land, infrastructure, and people, making this province particularly interesting for the next study phase. According to the WI, the provinces of Pistoia and Massa Carrara score high values. In Pistoia, the CI indicated low information levels. Despite a positive trend in the CI, the area is noteworthy in Massa Carrara due to rainy summers and a concentration of wildfires in the winter season (Tuscany Region Forest Department).

4.2.2 | Recognition of CAs

While significantly affected by fires over time, Grosseto province witnessed an increase in media coverage (in terms of news frequency) during the second five-year period of the study, so the final CI decreased in the last years. The region, characterised by seasonal tourism with a considerable impact on the coastal area, is actively developing a Firewise Community (NFPA - National Fire Protection Association, 2019; Uyttewaal et al., 2023). These factors collectively render Grosseto an intriguing area for studying risk perception.

The situation remained particularly critical in Lucca province, with consistently high wildfire index values and low media coverage throughout our study. Despite this, some programmes aimed at raising awareness about wildfire risk were organised by local *Protezione Civile* in recent years, offering the potential for fascinating insights into risk perception. Pisa province was selected primarily due to its historical forest fire susceptibility and fluctuating media coverage of wildfire events over the past decade. Additionally, establishing two Firewise Communities after a significant wildfire in 2018 adds to its appeal for studying forest fire risk perception.Pistoia was not considered as it falls outside the area of cooperation for the Med-Star project, which facilitated this study. Massa Carrara was excluded due to its already satisfactory level of CI. Nonetheless, these areas could be included in future studies of a similar nature. Finally, the recognised CAs fall inside the provinces of Grosseto, Lucca, and Pisa. The work follows with community engagement and a risk perception analysis in these areas (Calvani et al., 2025).

5 | CONCLUSIONS

This study highlights the critical role of media analysis in understanding wildfire awareness and communication patterns. Media analysis (RQ I) revealed that Tuscany is an Italian region with substantial wildfire-related communication, often tied to significant events. Newspaper interest in wildfire topics surged after 2017; this can be particularly seen in chronicle articles covering larger burned areas. With its broad reach, Twitter provided real-time wildfire reports, though its accuracy was occasionally compromised due to verification challenges. To enhance future research, incorporating a wider range of media sources will be crucial in mitigating platform-specific limitations. Beyond the case study, this research demonstrates how communication trends can indicate public awareness, even though they alone cannot fully capture risk perception. By integrating additional parameters, we developed an approach to identify CAs (RQ II, RQ III).

The correlation between media habits (a social parameter) and wildfire occurrence (an environmental factor) offers a new perspective on assessing wildfire risk perception. While Tuscany served as an area of investigation, the methodology and findings have broader applications in wildfire-prone regions worldwide, particularly in Mediterranean-type climates, where rural land abandonment and evolving communication dynamics shape risk awareness. The WI/CI Index provides a replicable framework for identifying areas requiring targeted awareness strategies (RQ III). Future research can expand this approach by integrating more diverse media sources and applying it to different geographical contexts, ultimately contributing to improved wildfire prevention and management on a global scale.

AUTHOR CONTRIBUTIONS

Calvani Silvia contributed to the methodological and experimental study design, data collection and analysis, acquisition and interpretation of results, figure design, manuscript writing, and manuscript revision. Foderi Cristiano contributed to the methodological and experimental study design, statistical data analysis, provided feedback during the research process, participated in the interpretation of results and discussion, and revised the manuscript. Paoloni Riccardo contributed to data analysis, provided feedback during the research process, participated in the interpretation of results and discussion, and revised the manuscript. Frassinelli Niccolò provided feedback during the research process, participated in the interpretation of results and discussion, and revised the manuscript. Neri Francesco revised the manuscript. Marchi Enrico contributed to the study design, data collection and analysis, interpretation of results and discussion, provided feedback during the research process, and revised the manuscript. All authors read and approved the final manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

The wildfire dataset used for this study is publicly available at the following link: https://www502.regione.toscana.it/geoscopio/incendiboschivi.html. The dataset generated from Twitter (through API Academic license) is available from the authors upon reasonable request. The web media dataset that supports the findings of this study is available from Twitter, but restrictions apply to the availability of these data, which were used under the Academic License for the current study and are not publicly available. Data are, however, available from the authors upon reasonable request and with the permission of Twitter [X]. The datasets generated from newspapers during the current study are not publicly available due to a formal request by the Directors. Other possible datasets are available from the corresponding author upon reasonable request.

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