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Characterisation and Analysis of Large Forest Fires (LFFs) in the Canary Islands, 2012–2024

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Abstract

In recent decades, forest fires have become one of the most disruptive and complex natural hazards from both environmental and territorial perspectives. The Canary Islands represent a particularly suitable setting for analysing wildfire risk. This study aims to characterise the Large Forest Fires (LFFs) that occurred across the archipelago between 2012 and 2024 through an integrative approach combining geospatial, meteorological, and socio-environmental information. A total of 13 LFFs were identified in Tenerife, Gran Canaria, La Palma, and La Gomera, affecting 55,167 hectares—equivalent to 7.4% of the islands' total land area. The results indicate a temporal concentration during the summer months and an altitudinal range between 750 and 1500 m, corresponding to transitional zones between laurel forest and Canary pine woodland. Meteorological conditions showed average temperatures of 24.3 °C, minimum relative humidity of 23.7%, and thermal inversion layers at around 270 m a.s.l., creating an environment conducive to fire spread. Approximately 81% of the affected area lies within protected natural spaces, highlighting a high level of ecological vulnerability. Analysis of the Normalized Burn Ratio (NBR) index reveals a growing trend in fire severity, while social impacts include the evacuation of more than 43,000 people. These findings underscore the urgency of moving towards proactive territorial management that integrates prevention, ecological restoration, and climate change adaptation as fundamental pillars of any disaster risk reduction strategy.

Keywords: vulnerability; adaptation; environmental governance; climate change; risk reduction

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1. Introduction

In recent decades, forest fires have become one of the most disruptive natural hazards, both environmentally and territorially. Their recurrence, extent and intensity have increased markedly in many regions, shaping a global-scale hazard that challenges territorial governance. This escalation results from the convergence of climatic, ecological and social processes which, under global warming, are altering the traditional balance between climate, vegetation and human occupation [1–3]. The intensification of Large Forest Fires (LFF)—the term used here for high-magnitude wildfire events—has been reflected not only in their greater frequency, but also in their dangerous dynamics, prolonged duration and significant economic and social impacts. Similar patterns have been documented in the Mediterranean basin, western North America, Chile and Australia, where extreme fire weather and land-use transformations have driven comparable increases in large, high-intensity events [4,5].

Beyond meteorology, fire is an eco-social phenomenon shaped by extreme atmospheric conditions—heatwaves, drops in humidity and prolonged droughts [5,6] and by land-transformation processes such as agricultural abandonment, landscape fragmentation and expansion of the wildland–urban interface (WUI). Numerous authors highlight the need for integrative perspectives that account for these interactions [7–9]. Within this framework, sixth-generation fires [10] represent the most extreme expression of this convergence: events capable of generating their own atmospheric dynamics, challenging suppression capacity and testing emergency systems at multiple scales. These characteristics have also been documented in recent megafires of Mediterranean-climate regions worldwide, reinforcing the global relevance of the processes described [5].

The Canary Islands offer a particularly suitable setting for analysing these processes. The archipelago's volcanic origin, rugged relief and marked bioclimatic gradients intersect with significant territorial transformations, including declining rural areas, protected forest zones and expanding urban nuclei. Its subtropical climate, shaped by Mediterranean influences [11], produces prolonged warm and dry periods. A key atmospheric element, the subsidence inversion, often descends during Saharan intrusions, exposing forested mid-altitude zones to extremely hot and dry air masses [12]. Combined with the abandonment of traditional agriculture, economic tertiarization and dispersed residential growth in mid-mountain belts, these factors have altered territorial structure and increased vulnerability to fire. Similar dynamics have been observed in Madeira and Hawai'i, where steep terrain and limited accessibility increase fire risk [13,14].

Schug et al. [15] show that this interface is expanding globally, not only in extent but also in density and structural heterogeneity. In the Canary Islands, former agricultural areas are increasingly occupied by scattered housing, roads and infrastructures, which increase fuel continuity and hinder suppression. This situation requires moving beyond traditional risk assessments based solely on meteorological parameters or forest mapping, as these tools no longer capture the current territorial configuration of fire [7,16,17].

For this reason, characterising wildfire risk in the Canary Islands requires an updated and cross-disciplinary methodological approach that integrates environmental, spatial, and social analyses. The growing simultaneity of fires, their erratic behaviour under extreme conditions and the emergence of sixth-generation events call for a re-evaluation of prevention and response systems. Recent studies [18–20] emphasise that LFFs on island ecosystems can have long-lasting effects, altering soil structure, vegetation composition and ecological dynamics. These findings align with broader evidence from other Mediterranean-type ecosystems, where post-fire recovery is increasingly conditioned by climate warming and fuel homogenisation [8].

Within this framework, a more precise understanding of fire dynamics in island contexts is thus essential. The topographic, atmospheric and land-use particularities of the Canary Islands require a methodological perspective that combines spatial analysis, environmental characterisation and the social interpretation of risk. Only through the joint analysis of satellite data, meteorology, land-use patterns and human exposure can the structural factors behind the recurrence and severity of forest fires be identified. This approach also allows temporal and territorial comparisons that improve prevention and emergency planning. Furthermore, the parallels with other Mediterranean-type and island ecosystems position the Canary Islands within broader discussions on evolving fire regimes.

This study aims to characterise the Large Forest Fires (LFF) that occurred in the Canary Islands between 2012 and 2024 through a comprehensive analysis of geospatial, meteorological and socio-environmental information. The specific objectives are: (i) to examine the spatial and temporal distribution of LFF; (ii) to analyse meteorological conditions at ignition and during fire spread; (iii) to investigate how fire perimeters intersect with

land-use patterns, protected areas and abandoned farmland, including their ecological effects through burn-severity indicators; and (iv) to assess immediate social impacts using evacuation data contextualised with demographic information.

Together, these dimensions offer an integrated view of fire dynamics in an insular and topographically complex environment. Understanding how climate anomalies, fuel structures, settlement patterns and land-use transformations interact is essential for improving fire prevention, territorial planning and climate-change adaptation in the Canary Islands. By placing the Canary Islands within the wider context of global fire dynamics, this study strengthens its comparative perspective and underscores the importance of insular environments for understanding changing wildfire regimes. Moreover, despite substantial advances in wildfire research across Mediterranean and island regions, few studies have jointly addressed the spatial, meteorological, social, and land-use dimensions of large fires in volcanic archipelagos, highlighting the specific knowledge gap that this work seeks to address.

2. Materials and Methods

For the development of this study, a georeferenced database of forest fires in the Canary Islands was compiled, from which a quantitative spatial analysis methodology was applied to characterise the dynamics, impacts, and conditioning factors of Large Forest Fires (LFF) in the archipelago. In this study, we considered LFFs as those affecting an area greater than 500 ha, in accordance with the Spanish forest fire statistics [21]. This approach made it possible to integrate information from various official and satellite sources, facilitating comparative analysis and the identification of territorial patterns associated with LFF.

Although LFFs have historically affected the Canary Islands, the systematic collection of data—particularly geospatial data—is a relatively recent effort. While inventories have existed since the 1980s [12], they are generally limited to reporting the total number of hectares burned or the number of events by province or autonomous community, without providing detailed information for each fire or precise event locations. With the emergence of satellite observation techniques and the advancement of Geographic Information Systems (GIS), the delineation and monitoring of such phenomena have improved significantly. In the case of the archipelago, the most detailed data are available through the Climate Governance System of the Government of the Canary Islands [22] and, complementarily, through the Copernicus Emergency Management Service [23]. Based on these two sources, which provide records since 2012, all LFFs occurring in the Canary Islands up to 2024 were identified.

The available data primarily include the perimeters of the affected areas, which enable precise determination of the extent and location of each fire and constitute the basis for subsequent spatial analyses. To facilitate the identification and interpretation of the information, a specific coding system was designed, combining the initials of each island with the month and year of the event. This allows each fire to be referenced clearly and unambiguously. Accordingly, the abbreviations used correspond to the initials of the affected islands: TF (Tenerife), GC (Gran Canaria), LP (La Palma), and LG (La Gomera). Thus, the code TF-8-23 identifies the fire that occurred in Tenerife in August 2023, whereas GC-9-17 refers to the fire in Gran Canaria in September 2017.

In this study, the selected indicators were chosen because they capture the primary environmental, atmospheric, and territorial drivers of wildfire behaviour and impacts identified in the scientific literature and operational risk assessment frameworks. Topography, meteorological conditions, land-use patterns, vegetation cover, and population exposure represent the core dimensions of fire hazard, fuel continuity, and social vulnerability, and constitute the variables for which consistent, spatially explicit data were available for all

events in the 2012–2024 period. Other potentially relevant variables, such as fuel moisture content, suppression resource deployment, or ignition causes, were not included because homogeneous and comparable datasets for the entire series of fires do not exist, and their incorporation would have introduced methodological inconsistencies and hindered cross-event comparability. Therefore, the selected indicators offer a robust and coherent basis for analysing LFFs in the Canary Islands while ensuring methodological consistency across the full study period.

2.1. Spatial and Territorial Characterisation of LFF

Before addressing more specific analyses, it is essential to establish a general characterisation of each LFF. This stage allows for the spatial and temporal contextualisation of the events and for understanding the physical conditions of the environment in which they developed. The identification of key elements—such as the ignition point, duration, or topography of the affected terrain—provides a solid foundation for subsequent analyses of patterns, risks, and processes associated with wildfires in the Canary Islands.

The general characterisation was approached through two complementary axes: (1) an administrative analysis and (2) a physical–topographical analysis. In the first case, the insular and municipal administrative units were considered to identify the regions most affected by fires. To this end, indicators such as the number of municipalities affected, the burned area, and the number of recorded fires in each unit were calculated using Geographic Information Systems (GIS).

Regarding the physical variables of the terrain, these were derived from the Digital Terrain Model (DTM25) provided by the National Geographic Institute (IGN). These variables encompass natural characteristics that not only influence fire intensity and spread but are also crucial for the management and planning of suppression operations. For instance, slope determines the speed and direction of fire and wind propagation; aspect influences these same factors as well as the moisture of vegetative fuels; and altitude affects temperature, relative humidity, and vegetation composition [24]. In the case of the Canary Islands, topography varies notably between islands, ranging from flat areas to mountainous regions with steep slopes. This orography, together with the elevation of certain zones, significantly conditions wildfire dynamics. Likewise, the difficulty of access to some locations represents an additional challenge for firefighting operations. These variables were included to characterise the physical terrain context of LFF, rather than to propose new hypotheses, as their effects on wildfire dynamics are already well established in the literature.

2.2. Meteorological Conditions

Meteorological conditions have a significant impact on the development of forest fires, as they directly influence fire behaviour and propagation. The collection and analysis of these data assist wildfire management authorities in making specific decisions regarding evacuation, resource allocation, and suppression strategies [25]. To determine the prevailing meteorological conditions on the ignition day of each fire, data were obtained from the Spanish Meteorological Agency (AEMET), including maximum, mean, and minimum temperature; maximum, mean, and minimum relative humidity; average wind speed; and maximum wind gust recorded on the day each LFF began. For each fire, a reference meteorological station located near the ignition point was selected, assuming that the environmental conditions at that station were similar to those at the ignition area. Additionally, in order to characterise the altitude at which the thermal inversion layer typically occurs, atmospheric sounding data from the Güímar station (60018) were collected. These data, archived by the University of Wyoming (2025) [26], are based on daily radiosonde measurements.

To minimise the uncertainty associated with the strong altitudinal gradients of the Canary Islands, the meteorological station used for each fire was selected not only by proximity but also by its elevation and environmental similarity to the ignition area. This criterion reduces microclimatic discrepancies, although local variations cannot be completely avoided. Consequently, the recorded values should be interpreted as representative approximations of ignition conditions, ensuring both environmental coherence and comparability across the 2012–2024 series.

2.3. Impact Assessment of LFF

2.3.1. Land Use and Protected Areas

Forest fires generate significant impacts on the environment, the economy, and society. Assessing these effects not only enables the quantification of the damage caused by each event but also allows for the identification of vulnerability patterns and the development of targeted prevention and management strategies. In the case of the Canary Islands, this evaluation is particularly relevant due to the high ecological value of their natural areas and the close proximity between forest zones and inhabited areas.

For the analysis of environmental impacts, data relating primarily to land use and the location of Protected Natural Areas (PNA) were used. In the Canary Islands, these protected areas correspond to the categories defined within the Canary Islands Network of Protected Natural Areas [27], which includes National Parks, Natural Parks, Rural Parks, Natural Monuments, Protected Landscapes, Integral Nature Reserves, Special Nature Reserves and Sites of Scientific Interest. Each of these categories entails specific management objectives and regulatory constraints that shape the degree to which fuel reduction, silvicultural treatments or accessibility improvements can be carried out, making them essential for interpreting territorial conditions relevant to wildfire prevention and suppression. The main source was the Copernicus Corine Land Cover, which provides a homogeneous and standardised land-use classification at the European scale, allowing for comparison with other territories. This dataset made it possible to distinguish between natural and anthropogenic land uses, including forest masses, agricultural areas, and discontinuous urban zones. Additionally, abandoned agricultural surfaces were specifically identified using the Crop Map of the Canary Islands [28], which enabled differentiation between areas still under cultivation and those that have been left fallow.

In order to contextualise the land-use layers employed in this study, it is important to note that the current spatial configuration of the Canary Islands is the result of marked socioeconomic transformations over the past decades. The progressive decline of agriculture and livestock farming following the mid-20th-century rural exodus has led to substantial changes in the agroforestry mosaic, with a documented 29.2% increase in forested land due to the abandonment of traditional uses, widespread reforestation efforts and the legal protection of extensive forest areas [29]. Similarly, agricultural land has experienced a sustained reduction, with an 11% loss of cultivated surface since 2000 (Figure 1), reaching 40% in La Gomera and 20% in Tenerife [30], and with approximately one-third of all registered agricultural parcels currently abandoned [28]. These transformations provide the structural context that explains the present-day distribution of fuel loads, which is the basis for the environmental impact assessment carried out in this study. While the analysis relies on current land-use data, recognising these long-term processes clarifies why certain categories, such as abandoned farmland or expanding forest areas, play a key role in shaping contemporary wildfire impacts.

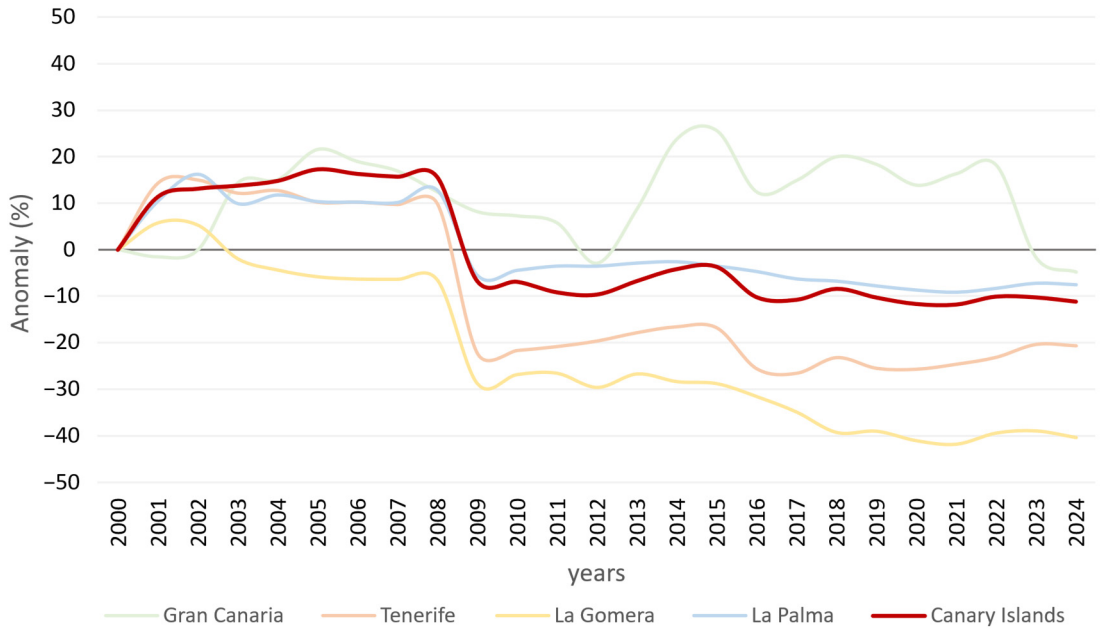


Figure 1. Annual Variation in Agricultural Land Surface Relative to 2000 (2000–2024).

2.3.2. LFF Severity

The analysis of wildfire severity in the Canary Islands was based on the application of the Normalized Burn Ratio (NBR) index. Satellite images were obtained through the Sentinel Hub EO Browser. However, since the Sentinel-2 satellite began operating in 2015, MODIS imagery was used for fires occurring before that date. Although MODIS provides lower spatial resolution (500 m compared to the 10–20 m of Sentinel-2), it offered suitable data for earlier events and ensured homogeneous coverage for the entire 2012–2024 series. Although the two sensors differ in spatial resolution, their spectral consistency enables the application of a uniform dNBR-based severity metric. As a result, severity values derived from MODIS should be interpreted at a broader spatial scale, whereas Sentinel-2 allows a more detailed depiction of internal burn patterns. This distinction does not compromise comparability between events, as the objective of the severity analysis is to characterise overall fire behaviour and relative intensity across the study period. The combination of both datasets thus provides the most complete and coherent representation of severity available for long-term wildfire analysis in the archipelago.

The NBR index was calculated using the following expression:

$$NBR = ((NIR - SWIR))/((NIR + SWIR)) \quad (1)$$

where NIR corresponds to the near-infrared band and SWIR to the shortwave infrared band.

This index enables the detection of variations in vegetation reflectance associated with biomass loss and the degree of surface charring after fire events. Based on pre-fire and post-fire imagery, the difference (dNBR) between both datasets was calculated. This result represents the net change in land surface conditions: higher dNBR values indicate greater fire severity, while values close to zero or negative correspond to unburned or regenerating areas.

For the interpretation of the obtained values, the standardised USGS classification proposed by Keeley [31] was applied, which distinguishes seven levels of burn severity according to dNBR ranges (Table 1).

Table 1. Fire severity levels defined according to dNBR thresholds.

Severity Level	dNBR Range	Description
High regrowth (post-fire)	−1.00 to −0.25	Strong vegetation regrowth after fire
Low regrowth (post-fire)	−0.25 to −0.10	Weak vegetation regrowth
Unburned	−0.10 to +0.10	Area not affected by fire
Low severity	+0.10 to +0.27	Light vegetation damage
Low–moderate severity	+0.27 to +0.44	Moderate vegetation damage
Moderate–high severity	+0.44 to +0.66	Significant vegetation damage
High severity	+0.66 to +1.30	Complete canopy consumption

The results obtained from the dNBR index formed the basis for a range of spatial and statistical analyses aimed at understanding the dynamics and conditioning factors of forest fires in the Canary Islands. From these derived products, comparative analyses were conducted to identify spatial patterns of impact and to assess the influence of variables such as vegetation cover, derived from the Real Vegetation Map of the Canary Islands [28]; terrain slope, calculated from the Digital Terrain Model of SITCAN (25 m resolution); and the total fire extent on the intensity of the recorded damage.

2.3.3. Direct Social Impacts

For the analysis of direct social impacts, information on evacuations and casualties was compiled primarily from national and regional media sources, complemented where possible by official press releases and institutional communications issued by emergency management authorities. The reliance on media sources reflects the absence of systematically published evacuation figures in official post-event reports for large wildfire emergencies, making media coverage the most consistent source of information across all analysed events.

Evacuation figures were cross-checked whenever possible using multiple independent media outlets and official statements released during the emergency phase by regional governments, civil protection services, emergency coordination centres, fire services and municipal authorities. Data were collected retrospectively, focusing on the active emergency phase and the initial days following fire containment, when evacuation orders were most frequently reported. When different evacuation figures were reported for the same event, priority was given to values confirmed by official statements. In the absence of consistent official figures, the most frequently reported value across media sources was retained. When evacuation numbers evolved over time, the highest reported figure was selected, as it represents the maximum number of people affected during the event.

Evacuations were selected as the primary indicator of social impact because they constitute the most immediate operational expression of population exposure during wildfire emergencies and are the only demographic indicator that can be consistently reconstructed across all events. To contextualise evacuation figures, demographic data from the Canary Islands Statistics Institute [30] were used to calculate the proportion of evacuees relative to the resident population of each island in the corresponding year.

Evacuation figures are subject to uncertainty, as they are largely derived from media reporting and may vary depending on the source, timing of data collection and evolving emergency conditions. These values should therefore be interpreted as approximate estimates of population displacement rather than precise counts.

To complement evacuation-based indicators, potential population exposure was quantified using a spatially explicit approach based on the intersection between fire perimeters and gridded population data. Population data were obtained from Eurostat population grids adapted to the Canary Islands and resampled to a spatial resolution of 250 m [32],

providing a harmonised representation of resident population distribution across islands and years.

For each wildfire event, the fire perimeter was intersected with the population grid corresponding to the year of occurrence. Population exposure within the burned area was calculated by summing the population values of all grid cells intersecting the fire perimeter. As all grid cells have identical spatial resolution, no additional area weighting was applied.

To capture potential exposure in surrounding residential areas, a 1 km buffer was generated around each fire perimeter. Population located within this buffer was estimated by intersecting the buffered perimeter with the corresponding population grid and summing the population values of intersecting cells. This buffer-based metric provides an estimate of population potentially affected by emergency measures beyond the burned area.

Unlike evacuation data, these exposure metrics are independent of emergency response decisions and allow for a consistent spatial assessment of potential social exposure. Results should be interpreted as indicative estimates, subject to uncertainty related to grid resolution and population distribution within cells.

3. Results

3.1. Spatial and Territorial Characterisation of LFF

This subsection summarises the main spatial patterns of LFFs across islands, municipalities and elevation ranges. Over the past 14 years (2012–2024), a total of 13 forest fires have been recorded in the Canary Islands (Figure 2). These occurred on Gran Canaria, Tenerife, La Palma, and La Gomera—the islands of greatest elevation—where climatic conditions favour the development of dense and diverse vegetation, thus promoting the occurrence and spread of LFF. In contrast, Lanzarote and Fuerteventura, which are considerably more arid, lack the dense vegetative formations required to sustain fires of such magnitude.

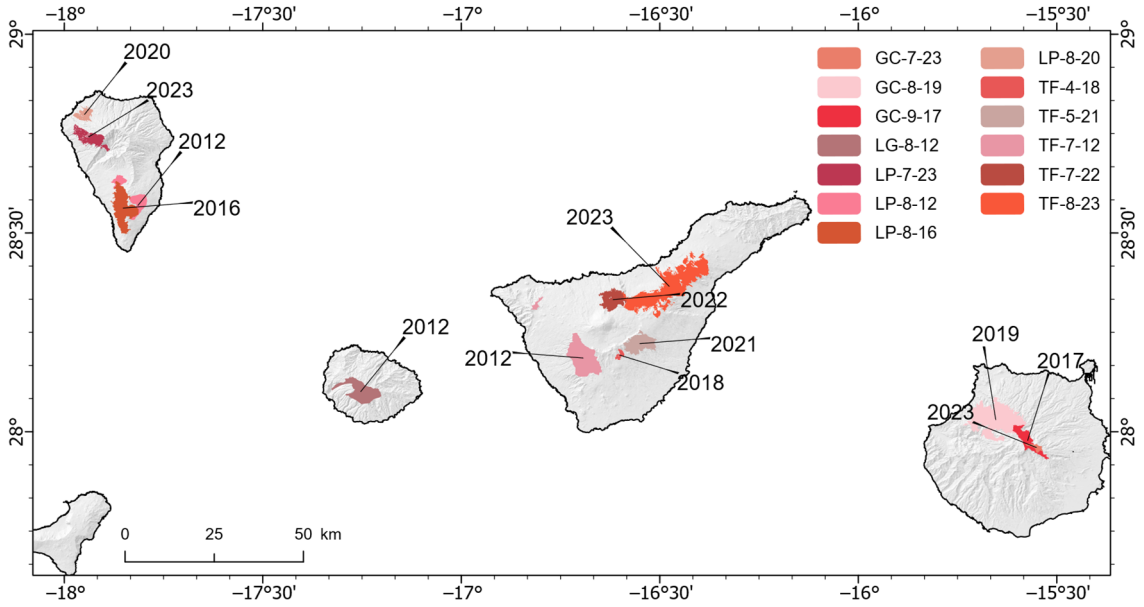


Figure 2. Location of identified LFF.

During this period, a total of 55,167 hectares burned, representing 7.4% of the archipelago's total land area. The recorded fires varied widely in size and duration (Table 2). The largest event occurred in August 2023, burning 13,977 ha and affecting 13 municipalities. It was followed by the 2019 Gran Canaria fire, which burned 9783 ha. In contrast, the smallest event occurred in April 2018 on Tenerife, affecting a single municipality and burning 391.89 ha.

Table 2. Summary of Large Forest Fires Analysed in the Canary Islands (2012–2023).

Fire Event	Burned Area (ha)	Perimeter (km)	Municipalities Affected	Duration (Days from Declaration to Containment)
TF/7/12	6277.80	57.71	8	7
LG/8/12	3961.92	49.48	6	52
LP/8/12	2698.18	41.75	3	5
LP/8/16	4863.99	59.26	4	9
GC/9/17	2446.87	54.68	7	4
TF/4/18	391.89	15.90	1	5
GC/8/19	9783.23	126.17	10	9
LP/8/20	1177.99	36.56	1	5
TF/5/21	3087.90	44.84	2	5
TF/7/22	2752.90	46.19	4	10
LP/7/23	3301.41	93.82	3	8
GC/7/23	446.22	15.24	3	3
TF/8/23	13,977.05	304.59	13	28

The comparison between the burned areas and the perimeters of the recorded fires (Table 2) reveals considerable variability in the magnitude and shape of the events. The largest fire, both in area and perimeter, occurred on Tenerife in August 2023 (TF/8/23), affecting 13,977 hectares with a perimeter of 304.6 km. It was followed, in terms of burned area, by the 2019 Gran Canaria fire (GC/8/19), which affected 9321.1 ha with a perimeter of 126.7 km, and by the 2012 Tenerife fire (TF/7/12), which burned 6277.8 ha with a perimeter of 57.7 km. Conversely, the smallest fires occurred in April 2018 on Tenerife and July 2023 on Gran Canaria, burning 391 and 446 ha, respectively, with perimeters ranging between 15 and 16 km. These differences between burned area and perimeter illustrate the wide variability in fire size and shape among events

In terms of temporal distribution (Figure 3c), August shows a high concentration of large-scale fires, due to climatic conditions favourable to fire spread. In this regard, 59% of these fires occurred between July and August, coinciding with the warmest period of the year in the archipelago, with four and six events, respectively. During these months, fires reached the largest average burned areas—3194 ha in July and 6077 ha in August. Together, these two months account for the majority of the total burned area, reaching 36,342.94 ha. Nevertheless, fires were also recorded outside the typical fire season, such as in April, May and September, although these do not correspond to the hottest periods in the archipelago. Only one fire was recorded in each of those months. The latest fire in the record occurred in September 2017, burning 2476 ha.

In terms of temporal duration (Figure 3b), during the analysed period a total of 150 days were marked by the presence of uncontrolled or unstabilised Large Forest Fires (LFF). On average, each fire lasted 11.5 days, although substantial temporal variability was observed. The longest events corresponded to major fires such as the August 2012 fire on La Gomera, which persisted for 52 days and affected six municipalities, and the August 2023 fire on Tenerife, which lasted 28 days. In contrast, 46% of the fires lasted fewer than five days. The correlation between burned area and fire duration was low ($R^2 = 0.14$), indicating high variability in response capacity and containment effectiveness.

A more detailed analysis reveals that La Palma is the island most affected proportionally by forest fires (Figure 4). Although the total burned area amounts to 10,859 ha—a figure lower than that of Tenerife—these areas represent 15.36% of the island's territory, making it the most impacted in relative terms. In total, the island has recorded four fires. Tenerife follows, with 24,730 ha burned—the highest absolute value in the archipelago—equivalent to

12.16% of its surface area, across five fires. In Gran Canaria, the three recorded fires affected 12,053 ha, representing 7.72% of the island's total area. Finally, La Gomera experienced a single fire that burned 3862 ha, equivalent to 10.51% of its territory.

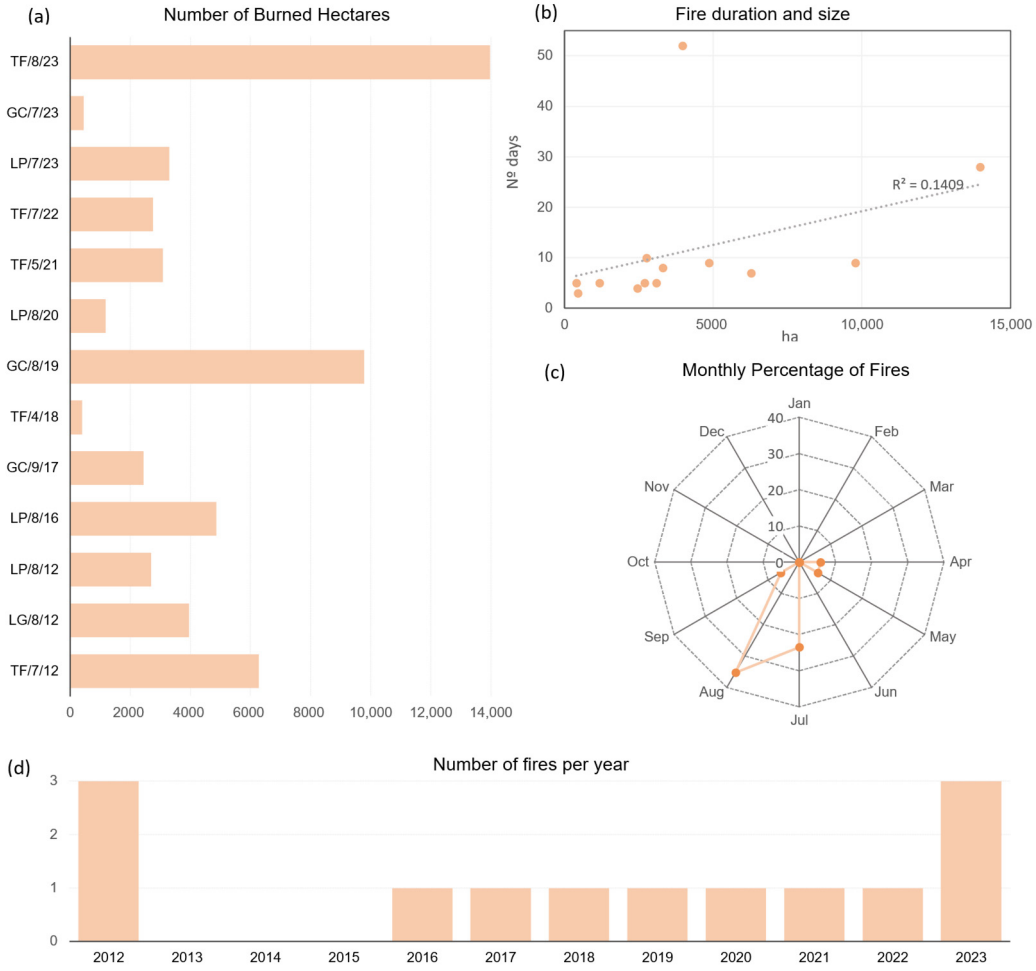


Figure 3. Overview of LFF events in the Canary Islands (2012–2024).

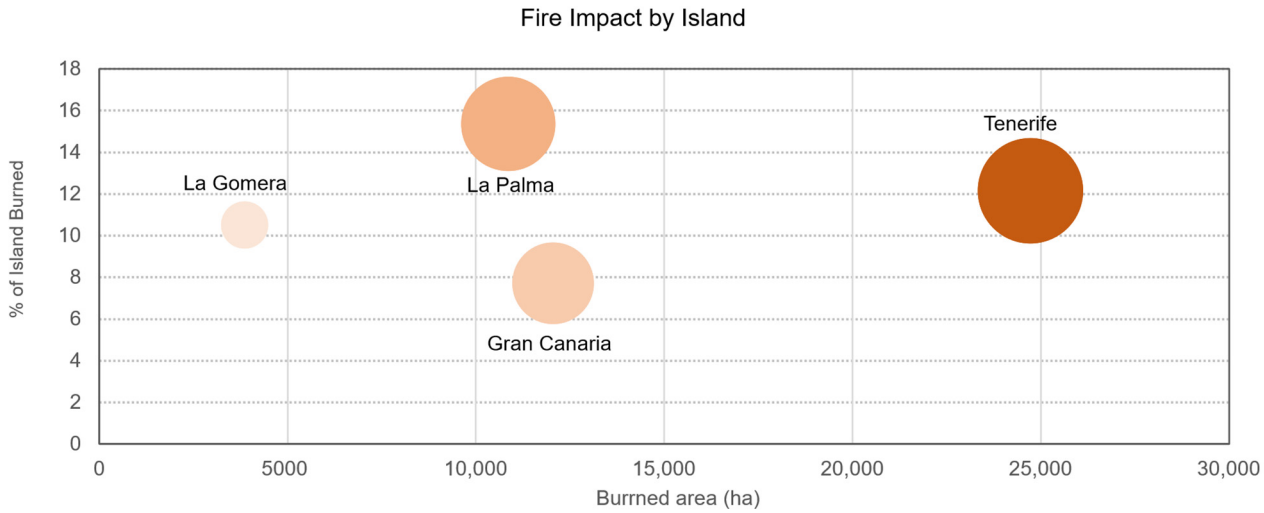


Figure 4. Relationship between total burned area and the percentage of island surface affected by wildfires in the Canary Islands (2012–2023). The bubble size indicates the number of recorded fires.

Regarding the most significant events on each island, the 2019 fire in Gran Canaria and the 2023 fire in Tenerife stand out, each affecting around 6% of the respective island's surface. In La Palma, the most severe event occurred in 2023, burning 2429 ha in just two days, equivalent to 3% of the island's total area.

When the scale is reduced, it becomes evident that 51 of the 88 municipalities in the Canary Islands were affected—to varying degrees—by at least one forest fire during the study period (Figure 5). The municipal-level analysis reveals significant differences in terms of total burned area, number of recorded fires and the average number of hectares affected per event. The mean burned area per municipality varies widely, ranging from very small values—less than 1 ha—to more than 3000 ha.

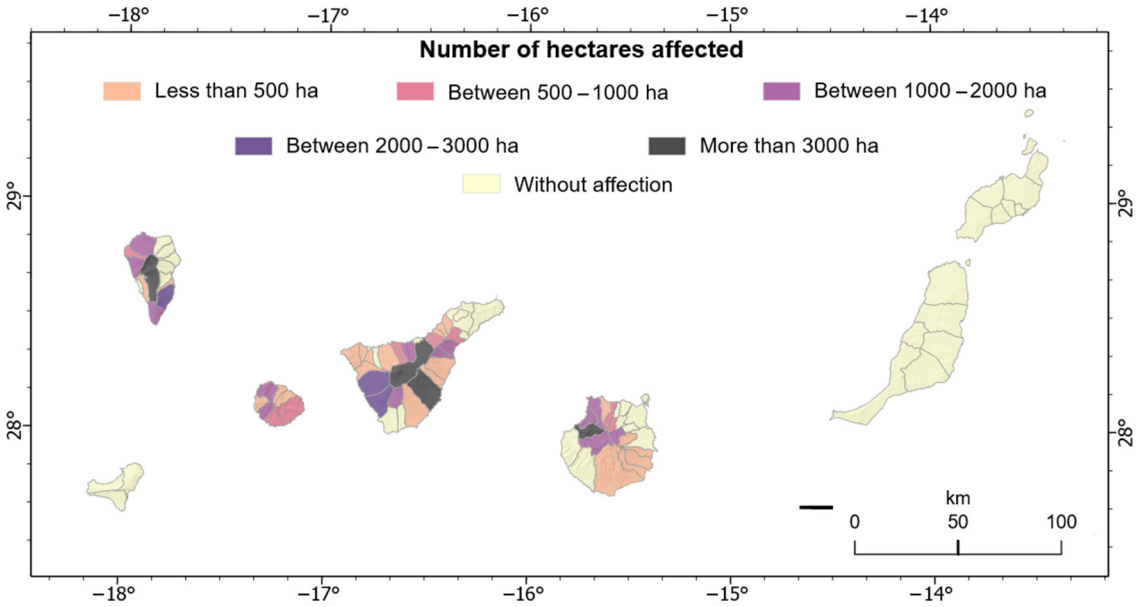


Figure 5. Burned area (hectares) by municipality in the Canary Islands during the 2012–2024 period.

In terms of total burned area, the most affected municipalities were La Orotava (Tenerife), with 4373.6 ha; Artenara (Gran Canaria), with 3816.4 ha; El Paso (La Palma), with 3355.9 ha; Arico (Tenerife), with 3083.5 ha; and Villa de Mazo (La Palma), with 2639.2 ha. In contrast, the least affected municipalities were Breña Baja (La Palma), with barely 0.002 ha burned; Buenavista del Norte (Tenerife), with 3.14 ha; and Agulo (La Gomera), with 38.97 ha.

The number of recorded fires also varied notably between municipalities. Most of them (65%, 33 municipalities) were affected by a single fire. The highest values were observed in La Orotava (Tenerife), with four fires, followed by Tejeda (Gran Canaria), with six, and Los Realejos (Tenerife) and Vega de San Mateo (Gran Canaria), with four and seven fires, respectively. In other municipalities, such as Tijarafe (La Palma), Vallehermoso (La Gomera) and Artenara (Gran Canaria), only one fire was recorded during the analysed period.

In terms of the average burned area per fire, the highest values were found in Artenara (3816.4 ha per fire), Arico (3083.5 ha per fire) and Vallehermoso (1462.9 ha per fire). At the opposite end, the lowest averages corresponded to Breña Baja (0.002 ha per fire), Agulo (38.97 ha per fire) and Ingenio (11.25 ha per fire). These results confirm La Orotava as the most affected municipality by forest fires across the entire archipelago. Viewed across both islands and municipalities, LFFs show a consistent concentration in areas with extensive forest cover, mid-altitude belts and rural–forest mosaics.

The recorded ignition altitudes of the analysed fires range between 541 and 1970 m above sea level, with a clear concentration at intermediate elevations—particularly between

750 and 1500 m—where 67% of ignition points were located. The most frequent altitudinal range for fire ignition corresponds to 1000–1250 m, with three fires, representing approximately 23% of the total. Below 500 m, only one fire was recorded (La Gomera, 2012), while above 2000 m the number of ignition points was very limited, restricted to exceptional events such as those that occurred on Tenerife in 2018 and 2023, which began at around 1970 and 1605 m, respectively.

Figure 6 shows the distribution of the burned area by altitude. It can be observed that areas situated between 1000 and 1500 m concentrate the largest proportion of burned surface—exceeding 40% of the total—followed by the 750–1000 m and 1500–1750 m ranges, each accounting for approximately 20–25%. These altitudinal bands largely correspond to transition zones between laurel forest and Canary pine woodland, characterised by high biomass and continuous fuel. Although most fires ignite at mid-altitudes, the affected area often extends upslope, frequently reaching 2000 m. Above this threshold, burned area decreases considerably, representing only about 6–7% of the total. Nonetheless, some isolated events, such as the 2019 Gran Canaria fire, reached elevations exceeding 2200 m, affecting even high-mountain ecosystems. At the opposite end, areas below 500 m have been scarcely affected, with the exception of Tenerife (2021) and La Palma (2023). Taken together, ignition points and burned area distribution outline a consistent altitudinal concentration of LFFs between 750 and 1500 m.

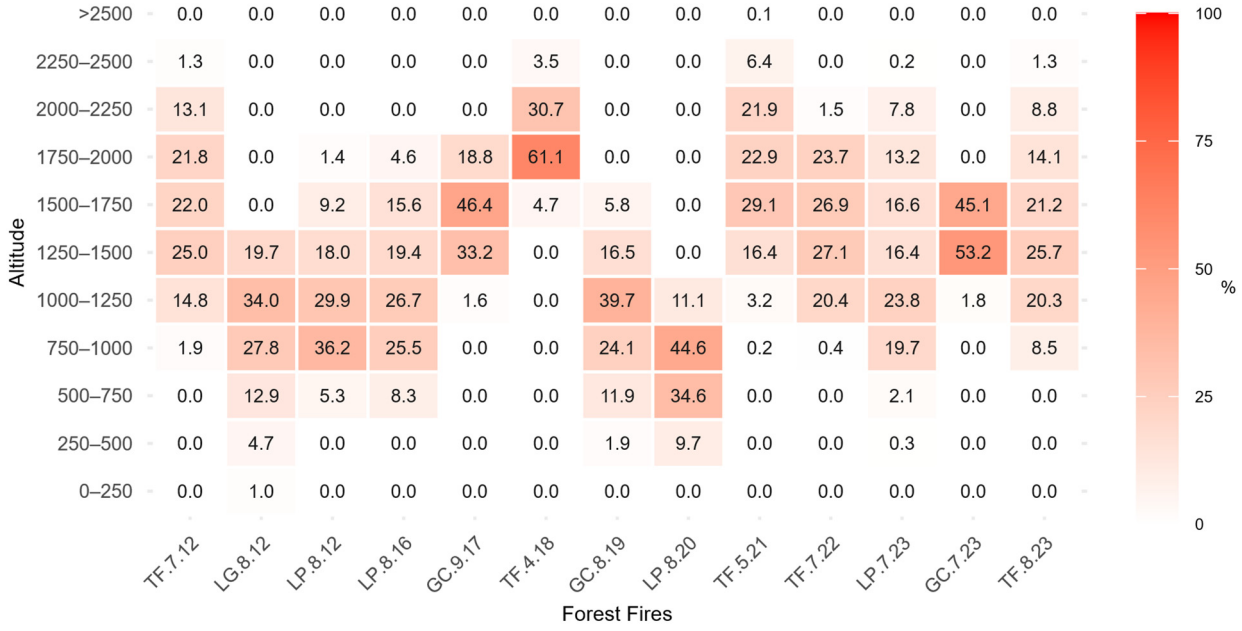


Figure 6. Distribution of burned area by altitude range. Values represent the percentage of burned area within each elevation interval.

Overall, these results outline a well-defined spatial footprint of LFFs in the archipelago, marked by their recurrence in mid-mountain belts and in municipalities with a strong rural–forest configuration.

3.2. Meteorological Conditions

Meteorological conditions play a fundamental role in the behaviour and propagation of forest fires in the Canary Islands. Among the most influential factors are temperature, relative humidity, wind speed, maximum wind gusts and the altitude of the thermal inversion layer. This section presents an analysis of the main meteorological conditions observed in the fires under study (Table 3).

Table 3. Summary of meteorological conditions recorded during the wildfire event.

	Mean	Maximum	Minimum
Maximum temperature (°C)	29.3	36.5	25.4
Minimum temperature (°C)	19.3	27.5	16
Mean temperature (°C)	24.3	32	21.8
Maximum relative humidity (%)	68.9	98	17
Minimum relative humidity (%)	23.7	55	7
Mean relative humidity (%)	44.1	82	8
Mean wind speed (m/s)	3.0	10.3	0.8
Maximum wind gust (m/s)	10.9	22.2	5
Inversion layer height (m.a.s.l.)	268.6	1034	123

In general terms, temperature is the primary meteorological factor influencing the ignition and spread of forest fires. The average temperature on the ignition day of the analysed fires was 24.3 °C, with an average maximum temperature of 29.3 °C and an average minimum of 19.3 °C. The extreme values recorded corresponded to a maximum of 36.5 °C and a minimum of 16 °C. These data reflect high thermal conditions and a pronounced daily thermal amplitude, particularly relevant for fires occurring in mid-altitude zones. It is worth noting that in the case of the 2019 Tenerife fire, which occurred entirely above 2000 m a.s.l., temperatures were considerably lower than those typically recorded in events at lower elevations.

Another variable with a major influence on fire spread is relative humidity. On average, the mean relative humidity was 44.1%, with minimum values as low as 7% (Tenerife, July 2012) and maximum values up to 82% (Tenerife, 2022). The average minimum relative humidity was 23.7%, while the average maximum reached 68.9%, indicating significant variability among different fire episodes. The 2023 La Palma fire stood out for recording the highest humidity values, peaking at 98%, in contrast to the extremely dry conditions observed during the 2012 Tenerife fire, which registered the lowest humidity levels.

In terms of wind, although it is another determining factor in wildfire dynamics, the recorded average speeds were not exceptionally high. The mean wind speed was 3.0 m s^{-1} (≈10.8 km h^{-1}), with an average gust of 10.9 m s^{-1} (≈39.2 km h^{-1}). The maximum observed gust reached 22.2 m s^{-1} (≈80 km h^{-1}), while the minimum was 5 m s^{-1} (≈18 km h^{-1}). These values indicate that, although wind conditions were not extreme, in some episodes higher gusts coincided with complex topography, particularly in ravine and slope areas.

Regarding the altitude of the thermal inversion layer, the data show that during the analysed fires in the Canary Islands it was located at an average height of around 270 m a.s.l., with maximum values reaching 1034 m and minimum values of barely 120 m.

In this sense, the meteorological data indicate a recurring pattern of warm and dry conditions during ignition days.

3.3. Impacts of LFF

3.3.1. Land Use and Protected Areas

The impact of forest fires in the Canary Islands reveals a clear differentiation between protected and non-protected areas, as well as among the various land-use categories affected. Overall, the results show a strong concentration of impacts within areas subject to some form of environmental protection, highlighting the high exposure of the archipelago's forest ecosystems.

The analysis of the thirteen fires recorded between 2012 and 2024 indicates that, on average, 81% of the burned area falls within protected natural areas, compared to 19% in unprotected zones (Table 4). The largest fires—such as Gran Canaria 2019, Tenerife 2012

and Tenerife 2023—occurred almost entirely within protected areas (over 95% of the burned surface). In total, 29 protected natural areas were affected.

Table 4. Protected Surface Affected by Each Fire Event (%).

Fire Event	% Protected Surface (ha)	Fire Event	% Protected Surface (ha)
TF-7-12	97.8	LP-8-20	0.1
LG-8-12	68.7	TF-5-21	100.0
LP-8-12	45.5	TF-7-22	98.8
LP-8-16	91.6	LP-7-23	8.4
GC-9-17	98.4	GC-7-23	100.0
TF-4-18	100.0	TF-8-23	94.5
GC-8-19	79.9		

In terms of protection categories, Natural Parks were the most impacted, with a total of 20,345 ha burned, representing 42% of the total affected area. They were followed by Protected Landscapes, with 8894 ha (18.4%), and Rural Parks, with 4958 ha (10.2%). National Parks and Nature Reserves showed lower levels of damage, although still significant from an ecological perspective.

Regarding land-use categories derived from Corine Land Cover, coniferous forests account for the majority of the burned area—over 27,000 ha throughout the period—followed by shrub and scrub vegetation (approximately 6200 ha) and sparse or transitional vegetation (around 6000 ha). These land covers are typical of mid- and high-altitude zones, where the accumulation of biomass and fuel continuity promote fire spread.

Agricultural land also showed a notable degree of impact, with a total of 2896 ha burned, representing 2.4% of the total affected surface. Although relatively minor compared to forest areas, these impacts are mainly concentrated in rural and peri-urban interface zones, where buildings and traditional crops are common.

In terms of crop types, data reveal a clear predominance of vineyards, which account for more than 620 ha affected during the study period. This land use was particularly impacted during the Tenerife 2023 fire (over 300 ha) and the La Palma 2016 fire (around 70 ha), followed by La Gomera 2012 and Gran Canaria 2019. Vineyards were followed in extent by temperate fruit orchards, with approximately 470 ha, particularly in Gran Canaria 2017 and La Palma 2023, where they exceeded 50 ha and 37 ha, respectively. Fallow land and pastures also showed a relevant presence, with more than 230 ha affected, mainly across Gran Canaria 2019, Tenerife 2012 and Tenerife 2023, reflecting the frequency of fires in abandoned or transitional agricultural zones. Other crop types affected to a lesser extent included vegetable plots, subtropical fruit orchards, citrus groves and banana plantations, the latter with just over 2 ha burned in total. The fires with the largest burned agricultural areas were Gran Canaria 2019 (over 230 ha) and Tenerife 2023 (almost 990 ha), followed by La Palma 2016 and La Gomera 2012, both exceeding 60 ha.

In addition, the most recent period (2020–2023) reveals a shift in the spatial pattern of fires, with several events occurring outside protected areas (Table 4), mainly in rural and peri-urban zones. The most notable cases correspond to La Palma 2020 and La Palma 2023, where over 90% of the burned surface was located in non-protected territory (99.9% and 91.7%, respectively). Land-use results therefore outline a clear predominance of burned area within protected forest landscapes.

3.3.2. LFF Severity

The results of the dNBR index reveal marked variability in the severity of forest fires recorded in the Canary Islands between 2012 and 2024 (Figure 7). Mean dNBR values range between 0.19 and 0.44, reflecting a spectrum from low-impact to moderate-to-high levels of

vegetation damage. In general terms, the most recent fires show higher average severity, particularly La Palma 2023 (mean dNBR = 0.39) and Gran Canaria 2017 (0.33), both of which recorded maximum values above 0.95, indicating the presence of extensive areas of high severity. In contrast, older events such as La Gomera 2012 (0.20) display lower values, associated with lower fire intensity and a greater proportion of unburned or regenerating areas. Overall, the severity results reveal a wide spectrum of burn responses across events, from predominantly low-severity fires to cases with extensive high-severity patches.

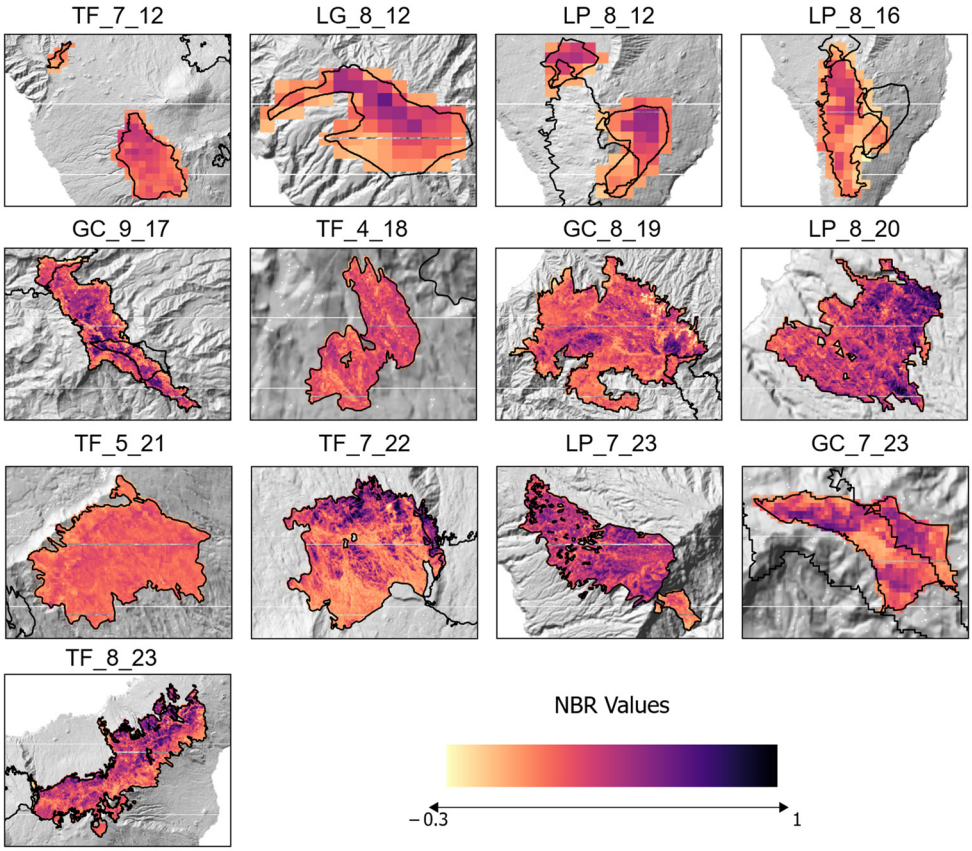


Figure 7. NBR-based spatial characterisation of burn severity for Large Forest Fires.

Figure 8 shows the percentage of burned area by the seven burn severity classes. Most fires fall within the low (30–50%) and low–moderate (20–35%) categories, while the extreme classes—high severity and high regrowth—represent much smaller proportions, generally below 10%. However, certain events such as La Palma 2023, Gran Canaria 2019 and Tenerife 2023 stand out for exhibiting a notable increase in moderate-to-high severity classes, with cumulative percentages exceeding 40% of their total burned area. Conversely, the La Gomera 2012 and La Palma 2016 fires show distributions dominated by low-severity and regrowth categories, exceeding 60% of their total surface area in these classes.

The temporal analysis of the mean dNBR index reveals a slight upward trend in wildfire severity in the Canary Islands during the 2012–2024 period (Figure 9a), with a coefficient of determination of R^2 = 0.23. Although moderate, this increase suggests an evolution towards fires with greater ecological impact over the past decade. Annual mean dNBR values range from 0.12 (2016) to 0.39 (2020), reflecting marked interannual variability influenced by meteorological conditions, fuel spatial distribution, topographic features and the management capacity associated with each event. Among the years analysed, 2016 and 2012 recorded the lowest mean severity values, corresponding to smaller fires with rapid vegetation recovery, whereas the highest values were observed in 2020 (0.39) and

2023 (0.33), coinciding with the La Palma and Tenerife fires, respectively. The highest mean dNBR values coincide with years in which large fires affected extensive forested areas on the western islands.

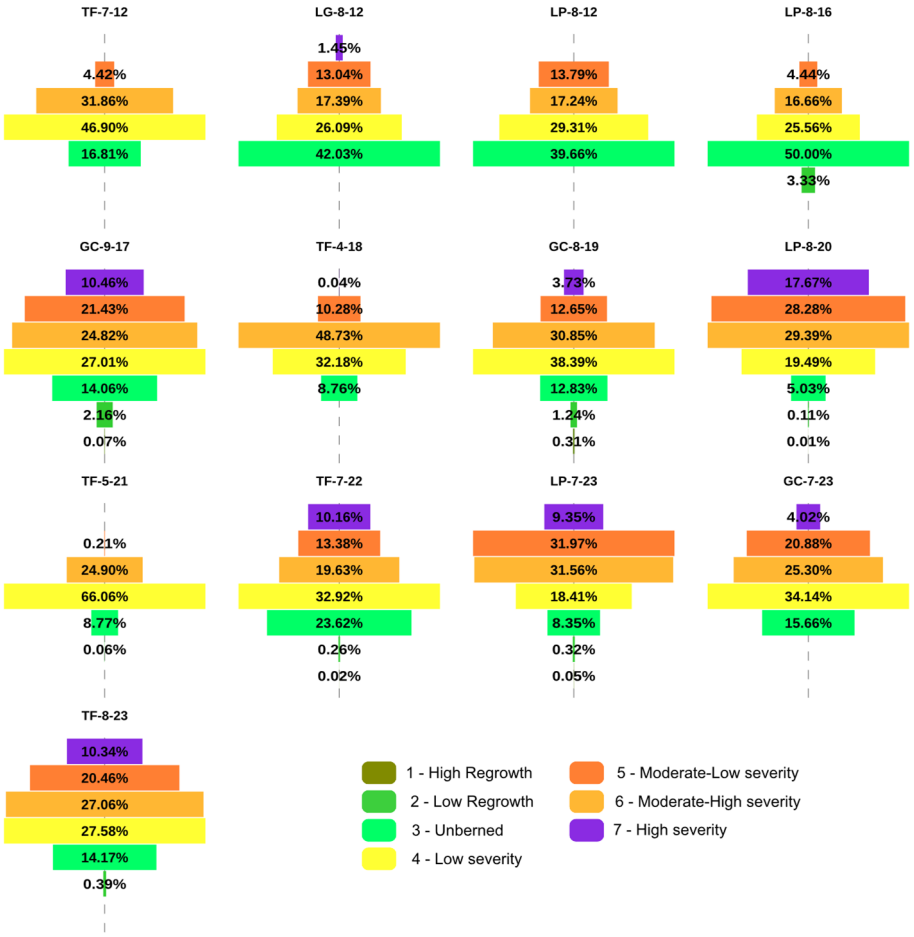


Figure 8. Proportion of burned area by severity class for each major wildfire, derived from dNBR thresholds.

The analysis of the relationship between burned area and mean fire severity (dNBR) does not reveal a significant correlation between the two variables (Figure 9b). The obtained coefficient of determination ($R^2 = 0.01$) indicates that fire size does not explain the variability in mean severity values. suggesting that a larger burned area is not necessarily associated with a greater impact on vegetation. Some small-scale fires, such as La Palma 2020 and La Gomera 2012, reached mean dNBR values comparable to or even higher than those recorded in larger events. such as Tenerife 2023 or Gran Canaria 2019. Temporally. the severity dataset exhibits a marked gradient. with several recent fires presenting higher proportions of mid- and high-severity classes

Across vegetation types, severity patterns remain highly variable, with distinct internal configurations depending on the dominant land cover. The analysis of burn severity by vegetation type and slope class highlights general ecological and topographic trends shaping fire behaviour in the Canary Islands (Figure 10). In terms of vegetation, higher mean dNBR values were observed in laurel forest and fayal–brezal formations (0.33), followed by thermophilous forest (0.30) and Canary pine forest (0.29). These vegetation types are characterised by high biomass density and relatively continuous fuel loads, which favour fire spread and the development of higher burn severity. Conversely, summit scrub

communities (0.17) and coastal halophilous scrub (0.15) show lower mean values, reflecting lower fuel availability and more discontinuous vegetation structures.



Figure 9. Descriptive evolution of mean burn severity (**a**) and its relationship with burned area (**b**). The dashed line represents a descriptive linear fit used only to illustrate general patterns, not as a formal temporal model. R^2 values indicate the strength of association but are not intended for inference.

However, despite these apparent differences, the variability of severity values between individual fire events is high, and a one-way ANOVA did not reveal statistically significant differences in dNBR among vegetation types ($F = 1.77$, $p = 0.15$). This indicates that inter-fire variability outweighs differences attributable solely to vegetation type.

Regarding slope, mean severity increases with gradient up to intermediate slopes (15–30°), where the highest mean value is recorded (dNBR = 0.34), and subsequently decreases on steeper terrain. Lower severity values are observed on very steep slopes (>45°), likely associated with reduced fuel continuity and more heterogeneous fire spread conditions. As in the case of vegetation, statistical analysis did not identify significant differences in dNBR among slope classes (one-way ANOVA, $F = 0.26$, $p = 0.90$), reinforcing the importance of event-specific factors in controlling burn severity patterns.

Overall, these results suggest that, while certain vegetation types and topographic settings tend to be associated with higher or lower severity levels, burn severity in large forest fires is primarily driven by inter-event variability, likely linked to meteorological conditions and fire dynamics at the time of each event.

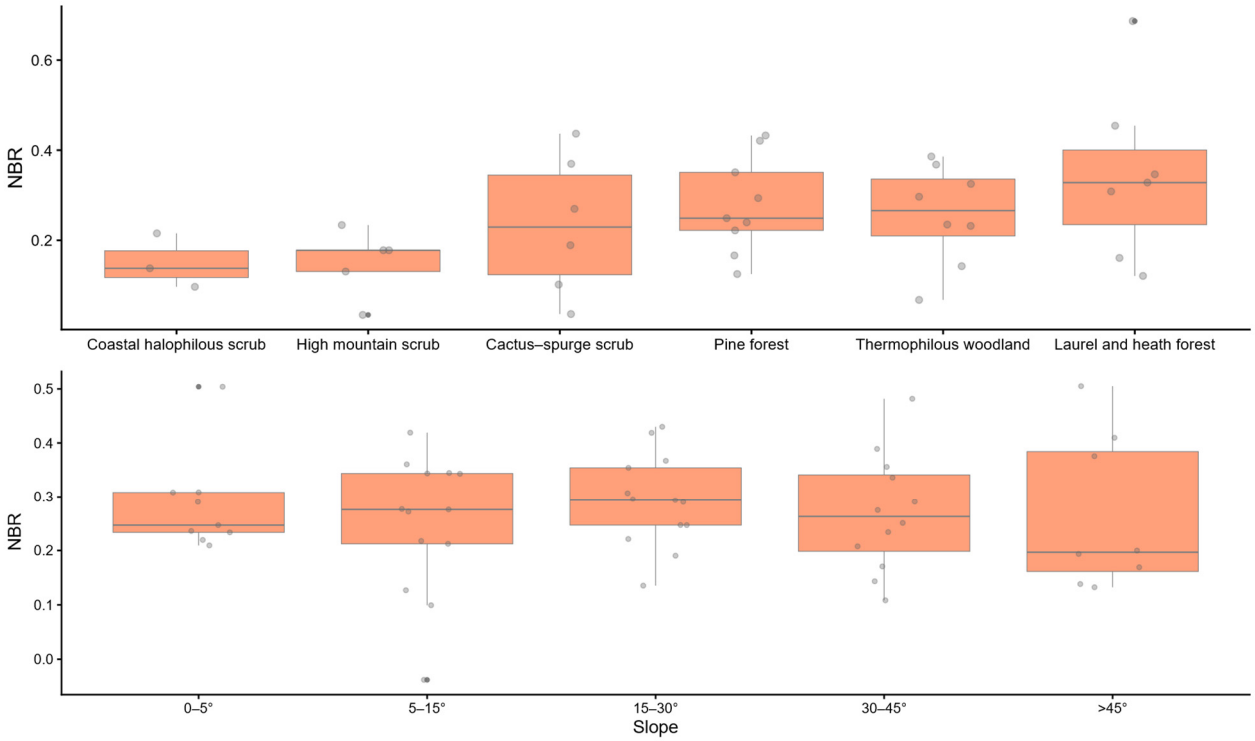


Figure 10. Burn severity (dNBR) distribution across vegetation formations (**above**) and slope gradients (**below**). Boxplots represent the median and variability of fire severity.

3.3.3. Direct Social Impacts

An additional dimension for assessing the social impact of large forest fires in the Canary Islands is population exposure. Potential exposure was estimated through the spatial intersection between fire perimeters and gridded population data, and further refined by considering a 1 km buffer around each fire perimeter to account for surrounding residential areas potentially affected by emergency measures. This approach allows population exposure to be analysed in a spatially explicit manner, independently of emergency response decisions.

The results show that population exposure within the burned perimeter is generally limited, with several fires presenting null or very low values, indicating that they occurred entirely in uninhabited or sparsely populated areas. For instance, the TF-4-18 and TF-5-21 fires intersected no resident population within the burned area, while other events such as LP-8-16 and LP-8-20 affected only a few hundred residents within the perimeter (201 and 279 people, respectively). By contrast, some recent events display substantially higher exposure values within the burned area, such as the July 2023 Tenerife fire, which intersected approximately 2582 residents.

When population exposure is assessed using a 1 km buffer around the fire perimeter, exposed population values increase markedly for most events and show strong temporal variability (Figure 11). Early events in the series, such as the August 2012 fires in La Gomera and Tenerife, already present notable buffer-based exposure values (4874 and 2387 residents, respectively), despite limited exposure within the burned perimeter. In La Palma, the August 2016 fire intersected 201 residents within the burned area, while 3527 residents were located within 1 km of the perimeter. The July 2023 Tenerife fire represents an extreme case, with approximately 25,166 residents located within 1 km of the fire perimeter, clearly standing out from the rest of the series. These results indicate that, even when direct exposure within the burned area is limited, a substantial proportion of the resident population may be located in close proximity to large fires.

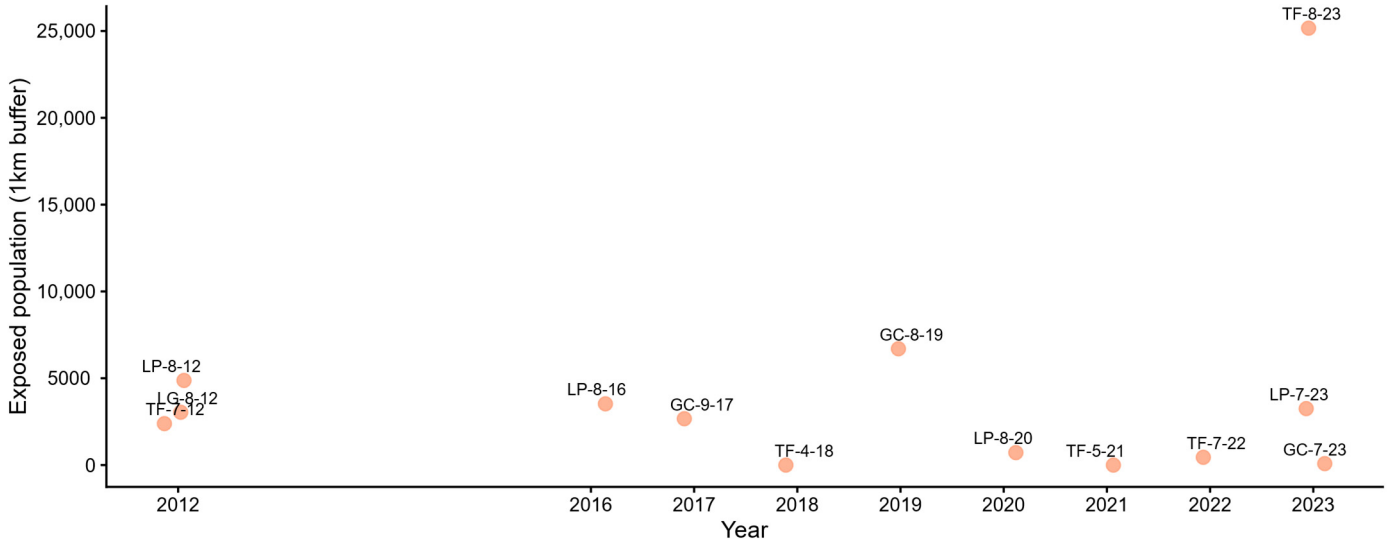


Figure 11. Temporal distribution of potentially exposed population estimated within a 1 km buffer around the fire perimeter for large forest fires in the Canary Islands (2012–2023). Points represent individual fire events.

Evacuation data provide a complementary perspective on social impact, reflecting the operational response adopted during each event and offering additional context to the exposure estimates. Over the 2012–2024 period, approximately 43,160 people were evacuated, corresponding to around 1.94% of the total population of the archipelago. Evacuation values vary markedly between islands and individual fire events, both in absolute and relative terms, reflecting differences in population size, settlement patterns and exposure conditions.

Some of the most pronounced evacuation impacts were recorded on smaller islands, where relatively limited absolute numbers translate into high proportions of the resident population. The August 2012 La Gomera fire led to the evacuation of approximately 5000 people, equivalent to 22.37% of the island's population, the highest relative evacuation rate observed in the series. In La Palma, the August 2016 fire resulted in around 2500 evacuees (3.07% of the island's population), while the July 2023 fire led to approximately 4000 evacuations (4.77%). In contrast, the August 2023 Tenerife fire stands out for recording the highest absolute number of evacuees, with approximately 26,000 people displaced, corresponding to 2.7% of the island's population.

Across events, high evacuation values tend to coincide with high buffer-based exposure estimates, indicating that evacuation measures were largely concentrated in areas with substantial residential presence in the vicinity of the fire perimeter. Conversely, fires characterised by low population exposure both within the burned perimeter and in the surrounding buffer generally correspond to limited or null evacuations, such as the July 2023 Gran Canaria fire or several events recorded between 2018 and 2021.

4. Discussion

4.1. Spatial and Territorial Patterns of LFF

The spatial patterns described in the results provide the basis for discussing the first objective of the study which focuses on how LFFs are distributed across islands. municipalities and elevation ranges. The results confirm that LFFs in the Canary Islands constitute a structural territorial phenomenon, closely linked to the combination of extreme meteorological conditions. rural abandonment, and high continuity of vegetative fuel. Between 2012 and 2024, more than 55.000 hectares were affected with a clear concentration of

events during the summer months and within altitudinal ranges between 750 and 1.500 m, coinciding with the transition zones between laurel forest and Canary pine forest. This distribution reflects the close relationship between climatic patterns and the biophysical characteristics of the archipelago, where high temperatures, low relative humidity, and easterly winds act as triggering factors in landscapes with abundant accumulated biomass. The concentration of LFFs in mid-altitude belts and summer months observed in our results coincides with patterns documented in other Mediterranean and Atlantic regions, where dry seasonality and the disappearance of the traditional agroforestry mosaic have increased fuel continuity and favoured larger and more severe fires [4,8]. This suggests that the LFFs recorded during the analysed period do not represent isolated anomalies but are instead linked to territorial transformations over recent decades that have intensified structural vulnerability to fire in insular environments.

From a spatial perspective, the configuration of the territory emerges as a key factor, with intermediate slopes (15–30°) and mid-mountain belts appearing as the most fire-prone zones in our results. The prominence of these altitudinal and topographic settings echoes findings by Lecina-Díaz et al. [33], who describe how terrain inclination accelerates fire spread and complicates suppression. Likewise, the lack of correlation between fire size and mean severity indicates that ecological impact depends less on total burned area than on local conditions—fuel structure, slope gradients and operational effectiveness—which is consistent with patterns reported in other island environments [13]. Several of the most affected municipalities are located in mid-altitude belts where forested areas and former agricultural terraces now form continuous vegetation cover. At the same time, the rugged topography and limited accessibility of many of these zones help explain the variability in final severity, underscoring the operational constraints associated with mountainous island terrain.

4.2. Atmospheric Conditions and Recent Evolution of LFF Severity

Examining the atmospheric configuration present during the fires, together with the observed severity patterns, allows us to advance the second objective of the study, centred on understanding how meteorological conditions influence fire behaviour. From a temporal perspective, the upward trend in the mean dNBR index (R^2 = 0.23) indicates a progressive increase in fire severity over the last decade. This behaviour suggests an evolution towards more intense fires, likely associated with regional warming, low relative humidity and the increasing occurrence of summer thermal inversions. Regarding the latter, the data show that the mean inversion height during the analysed fires was around 270 m a.s.l. with maximum values reaching 1034 m and minimum values of 120 m. Such a low inversion altitude favours the accumulation of warm and dry air at mid-levels, reducing ventilation and promoting rapid fire spread, particularly in mid-altitude zones and exposed slopes. This pattern is consistent with Correa and Dorta [12] who report that during ignition days of LFFs in the Canary Islands the base of the inversion layer typically lies around 300 m a.s.l. leaving much of the forest mass and inhabited areas outside the cooler, more humid lower layer of the atmosphere. Consequently, low and stable inversion layers emerge as one of the most decisive meteorological factors shaping fire genesis and behaviour in the archipelago, in line with recent observations in Madeira and Hawai'I, where inversion-driven instability significantly amplified fire spread, demonstrating how atmospheric anomalies can intensify severity under specific insular atmospheric regimes [13,14].

The upward trend in severity observed in our dataset aligns with patterns documented in other Mediterranean and island contexts. where warmer and drier atmospheric conditions have coincided with more extreme fire events [5]. Several authors have noted that increasing heatwaves and prolonged droughts contribute to more intense and less

predictable fire behaviour [2], a dynamic that resonates with the characteristics of recent LFFs in the Canary Islands. In this sense, the behaviour shown by some of the latest events, particularly Tenerife 2023, shares features described for high-intensity or 'sixth-generation' fires, including rapid escalation and strong interaction with local atmospheric conditions. These parallels suggest that the archipelago may be experiencing the early stages of a shift towards more severe fire dynamics, consistent with warnings issued for Southern Europe [5,8].

4.3. Land Use, Protected Areas and Territorial Drivers of Wildfire Risk

The land-use structure of the affected areas, together with the extent of protected landscapes, provides key elements for addressing the third objective, centred on the ecological and territorial conditions that shape fire behaviour. The insular nature of the archipelago introduces specific factors compared with continental regions: the limited territorial extent, the strong altitudinal variability over short distances and the rugged topography concentrate fires in hard-to-access areas where suppression operations become considerably more complex. Added to this is the proximity between forested areas and inhabited settlements which affects both fire spread and the strategies for evacuation and risk management. A progressive shift in fire impact towards rural and peri-urban areas is evident in our results, particularly in the 2020 and 2023 La Palma events, where most burned area occurred in non-protected zones adjacent to settlements. These recent fires illustrate how LFFs increasingly intersect with the wildland–urban interface (WUI), a pattern that coincides with broader territorial changes such as the decline of agricultural activity and the expansion of dispersed residential uses [15]. Similar tendencies have been documented in other fire-prone regions, including California, Portugal and Australia [4,17], suggesting that the increasing relevance of WUI areas in the Canary Islands fits within wider shifts in contemporary wildfire regimes.

Within this territorial context, a notable feature in our results is that 81% of the burned area is located within Protected Natural Areas (PNA), reflecting the concentration of high-biomass forest systems in these landscapes. This pattern underscores the importance of integrating fuel-management criteria into conservation planning, especially where protected forests lie in proximity to rural or peri-urban settlements. In this regard, recent studies emphasise the need to reconcile conservation policies with fuel management in protected landscapes affected by the growing climatic influence on wildfire risk [4]. Taken together, these elements demonstrate that land-use transformation and WUI expansion constitute central territorial drivers in the emergence of LFFs in the Canary Islands.

4.4. Social and Territorial Dimension of LFF Risk

The exposure and evacuation patterns analysed in the results offer a basis for examining the social dimension of LFF, which constitutes the fourth objective of the study. This social dimension is analysed through both evacuation outcomes and population exposure, allowing the realised emergency response to be interpreted alongside the underlying territorial conditions that shape social vulnerability. In this context, the relative proportions of evacuated population act as key indicators of insular vulnerability and institutional response capacity. On smaller islands such as La Gomera and La Palma, the percentage of evacuated residents is proportionally higher, reflecting greater physical exposure, more dispersed rural settlement patterns and more limited logistical resources. In contrast, the larger islands, equipped with more consolidated emergency systems, display relatively lower evacuation rates, suggesting a higher level of operational resilience [12]. Population exposure patterns further reinforce this interpretation, showing that fires intersecting or occurring in close proximity to populated areas tend to generate higher social impact, inde-

pendently of fire extent alone. This highlights that the social impacts of extreme fires are determined by the interaction between territorial vulnerability and institutional capacity to manage them. Recent studies indicate that socio-economic, structural and territorial factors critically condition the success of evacuation processes and institutional response during major fires [34]. Likewise, in the context of southern Europe, research has shown that the expansion of the wildland-urban interface (WUI) and dispersed urbanisation within forested areas generate greater vulnerability to fire and higher operational demands in evacuation and suppression [35,36].

4.5. Study Limitations and Future Research Directions

These results highlight the urgency of advancing towards active forest management and adaptive territorial planning aimed at reducing fuel continuity, restoring traditional agroforestry mosaics and reorganising land use around the WUI. In this regard, the findings align with the principles of the Sendai Framework for Disaster Risk Reduction 2015–2030 [37] which promotes informed risk management, reduced exposure and the strengthening of local resilience. Moreover, the recent literature on integrated fire management in Europe underscores the need for holistic approaches that combine territorial planning, adaptive silviculture and multilevel governance [38].

Despite the progress achieved, the study presents certain methodological limitations. First, the limited availability of geolocated wildfire data prior to 2012 restricts the historical analysis and hampers the identification of long-term trends. Second, the dependence on satellite resolution limits the spatial detail of the results: while Sentinel-2 imagery (10–20 m) allows for a precise delineation of high-severity areas, MODIS data (500 m), used for fires prior to 2016, reduces the ability to detect local variations. In addition, the absence of complete post-fire regeneration time series and the lack of detailed socio-economic data at the municipal scale constrain the integration of human and economic dimensions of risk. For these reasons, future analyses should incorporate longitudinal datasets and multi-sensor reconstructions to refine the understanding of severity trajectories and recovery processes.

Looking ahead, future research should aim to integrate dynamic risk models incorporating meteorological, topographic and fuel variables, as well as to develop multi-temporal post-fire analyses assessing vegetation recovery through spectral indices. Likewise, the inclusion of socio-economic and local governance indicators would enable progress towards a more holistic approach to risk, strengthening the understanding of territorial vulnerability and the effectiveness of management strategies in insular environments. Comparative research with other volcanic archipelagos would also help clarify common mechanisms and context-specific vulnerabilities.

5. Conclusions

This study provides an integrated, descriptive characterisation of thirteen Large Forest Fires (LFF) that occurred in the Canary Islands between 2012 and 2023. The results show that LFFs display a clear spatial pattern, concentrating mainly in mid-mountain belts (750–1500 m) and on intermediate slopes, where vegetation density and topography favour fire spread. Meteorological conditions consistently associated with these events include low relative humidity, high temperatures and, in several cases, low and stable subsidence inversion layers, which together contributed to rapid propagation under specific atmospheric configurations. Beyond this descriptive synthesis, the study addresses a relevant gap in wildfire research: the scarcity of integrated analyses for volcanic island systems, where topographic complexity, protected-area concentration and WUI configuration differ markedly from continental settings. By jointly analysing spatial distribution, meteorology,

severity, land-use structure and social impacts, the work offers a multidimensional perspective that was previously unavailable for the Canary Islands. This integration reveals how altitudinal structure, exposure within protected areas and the expansion of WUI belts interact to shape fire behaviour, providing evidence that complements and extends findings from continental contexts.

The descriptive analysis of burn severity indicates a moderate upward tendency in recent years, particularly in Tenerife, Gran Canaria and La Palma, although the limited number of events prevents drawing inferential conclusions. The lack of correlation between burned area and mean severity underscores the decisive role of local factors such as fuel structure, terrain and suppression effectiveness. These findings help explain why similar-sized fires can produce markedly different ecological outcomes.

From a territorial perspective, most burned area was located within Protected Natural Areas, where fuel accumulation favoured by limited management increases the susceptibility of these environments to high-severity fire. In parallel, the presence of burned sectors adjacent to rural and peri-urban settlements highlights the importance of considering population exposure in fire-risk management. In this regard, the proportion of evacuated population proved to be a useful relative indicator for comparing impacts across islands with different demographic structures.

The findings of this study also highlight several research priorities that emerge directly from the patterns identified. First, the strong concentration of LFFs between 750 and 1500 m emphasises the need for longer historical datasets capable of capturing how altitudinal fire regimes have evolved over time in island environments. Second, the observed variability in burn severity across events—together with the reliance on mixed-resolution imagery—underscores the importance of developing multi-sensor approaches that allow more consistent comparisons of severity trajectories, particularly within protected forest systems where impacts were greatest. Third, the increasing intersection between recent fires and WUI zones points to the need for socio-economic datasets that better represent exposure and vulnerability in dispersed rural and peri-urban settlements. Finally, the ecological heterogeneity revealed by severity patterns suggests that post-fire recovery processes may differ substantially between vegetation types and altitudinal belts, calling for multi-year monitoring frameworks tailored to volcanic island ecosystems.

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Data Availability Statement: The data presented in this study are available on reasonable request from the corresponding author. The data are not publicly available due to data management agreements.

Conflicts of Interest: The authors declare no conflict of interest.

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