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Article

Attica: A Hot Spot for Forest Fires in Greece

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Abstract: (1) Background: Forest fires are widespread in Mediterranean-climate regions and are becoming very common in urban and peri-urban areas. (2) Methods: Wildfires in Attica since 1977 are mapped and types of vegetation burned are reported. (3) Results: Fires are becoming larger. During the period of study (1977–2024), 45% of the burned area was covered with *Pinus halepensis* forests, 1.4% with *Abies cephalonica* forests, and 18.5% with shrublands. A relatively high percentage of the burned area (BA) affected more than once consisted of pine forests (65%). Ten percent of the total BA lies within the boundaries of the Natura 2000 network, Europe's most important network of protected areas, of which 38.9% was burned. At the interannual scale, the BA in Attica is negatively correlated with relative humidity, while reduced precipitation may contribute to the expansion of wildfires. (4) Conclusions: Fires are becoming larger over time, with low humidity increasing the higher fire risk. Since the changing climate is expected to create more severe and uncontrollable conditions, mitigation and adaptation measures should be planned and be introduced immediately.

Keywords: wildfires; *Pinus halepensis*; *Abies cephalonica*; shrublands; Natura 2000 sites; climate change

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1. Introduction

Fire is a natural phenomenon playing an important ecological role in several ecosystems [1] and especially in those having a Mediterranean-type climate. However, fire regimes seem to be changing in many regions of the world not only because of the effects of increasing temperature and reduced precipitation [2] but also because human activities are drastically changing the landscape configuration [3]. Europe has registered a high number of fires and an extensive burned area (BA) in recent decades [4,5]. The Mediterranean region is at the center of summer wildfires, with drought conditions and high temperatures contributing to the spread of larger fires [6]. All Mediterranean countries have experienced more and larger fires during recent decades [5]. According to the data derived from the Copernicus European Forest Fire Information System (EFFIS) program, Spain, France, Portugal, Italy, and Greece account for 78% of the total BA and 84% of the total number of fires recorded in Europe in the period of 2000–2021.

The example of Portugal is characteristic. Despite being a small country, the number of catastrophic fires it has experienced is remarkable [7]. The same holds for Greece, which ranks among the European Mediterranean countries with the most important records of forest fires, having shown measurable changes in intensity, extent, and frequency over the past decades. Kontoes et al. [8] reported that the southern and arid regions of Greece show a higher fire susceptibility than the northern and more humid ones for the period 2007–2011.

Since the late 1970s, satellite-based remote sensing data have been widely used to detect active wildfires and map BAs [9,10]. Landsat archives provide frequent Earth surface reflectance data from late 1980s with a spatial resolution of 30 m. These types of data make it possible to estimate fire size, the affected area, and burn severity. Mapping the BA can broaden the knowledge of the dynamics of the areas affected by fires worldwide, mainly because data analysis can be based on time series [10].

The aim of this study was to investigate temporal changes in fire regimes over Attica, a prefecture of Greece where Athens, the capital of Greece is situated. Attica is the most densely populated region of Greece, hosting half of the population of the country. Urban expansion often takes place at the expense of forested or shrubland areas, sometimes following intentional fires [11,12], even within protected areas [13]. As a highly populated region, Attica is particularly vulnerable to fire risk under future climate scenarios [14]. In the current study, fire events were studied not only numerically but also by mapping their extent through time, with the use of satellite images. Only few other studies have been published which report on fire events in Attica over a certain period of time (e.g., [14,15]), but none has reported on their spatial arrangement and the types of vegetation burned. Such studies are particularly important for regions such as Attica, where wildfires may result in numerous fatalities and severe consequences to the local natural and built environments, as was the case of Mati wildfire in Eastern Attica in 2018 [16].

2. Materials and Methods

2.1. Study Area

The study was performed in Attica Prefecture, located in Central Greece. The prefecture covers an area of 380,000 hectares (ha) and it consists of the mainland and a series of islands. In the current study, only forest fires that took place in the mainland mountainous areas were considered.

The climate of Attica is typical Mediterranean, with an extensive summer period and droughts lasting sometimes from April till October. The summer drought coincides with the fire season, which officially lasts from 1 May to 30 October, while for 2024 Greece's Fire Service has announced the extension of the fire season in several regions across the country until 15 November.

Attica Prefecture is in its greatest part a mountainous area [17], with Mt Parnitha in the northwest part being the highest one (1413 m a.s.l.). Mt Geraneia (1369 m a.s.l) and Mt Kitheron (1409 m a.s.l.) are located at the west part of the prefecture, whereas Mt Penteli (1108 m a.s.l.), Mt Ymittos (1026 m a.s.l), and Mt Paneion (615 m a.s.l.) are found in the east part across a north/south axis, while several lower mountains and hills are also present (Table S1, Supplementary Materials).

Within the limits of Attica, eight sites are included in the Natura 2000 Network, the pan-European network of protected areas, covering Europe's most valuable and threatened species and habitats. It contains two different types of protected areas, designated under the Birds and the Habitats Directives. In Attica, five of the Natura 2000 Network sites are characterized as Special Areas of Conservation (SACs) for the protection of habitats and species listed under the Habitats Directive [18]. Three (3) more sites are characterized as Special Protection Areas (SPAs) for the conservation of wild birds, in accordance with Directive 2009/147/EE, while Mt Parnitha is characterized both as a SAC and SPA (Table 1).

Table 1. Natura 2000 Network Sites within the limits of Attica Prefecture (SAC: Special Areas of Conservation, SPA: Special Protection Areas).

Site Code	Site Type	Site Name	Area (ha)
GR3000001	SAC—SPA	Oros Parnitha	14,921.81
GR3000003	SAC	Ethniko Parko Schinia—Marathona	1332.08
GR3000004	SAC	Vravrona—Paraktia Thalassia Zoni	2711.52
GR3000005	SAC	Sounio—Nisida Patroklou kai paraktia thalassia zoni	5382.27

Table 1. *Cont.*

Site Code	Site Type	Site Name	Area (ha)
GR3000006	SAC	Ymittos—Aisthitiko dasos Kaisarianis—Limni Vouliagmenis	8812.79
GR3000014	SPA	Periochi Legrenon—Nisida Patroklou	2107.13
GR3000015	SPA	Oros Ymittos	8319.47
GR3000016	SPA	Ygrotopos Schinias	2079.16
GR2530005	SAC	Ori Geraneia	6987.00

2.2. Mapping the BA

Data on fire events were retrieved from the literature [19] as well as the Copernicus EMS (Emergency Management Service) database. Only fires larger than 150 ha were included. Maps of fire events are provided in Figure 3 and Figures S1–S6 in Supplementary Materials for sequential time periods, starting from 1977–1979, followed by decade time intervals from 1980 onward, whilst the most recent period covers the years 2020–2024. Only fires that took place within the mainland of the Prefecture are considered, as several islands are included in the administrative boundaries of Attica. Fire perimeters were extracted semi-automatically by vectorizing polygons corresponding to lower values of the normalized difference vegetation index (NDVI), an index widely used for monitoring forest fires [20]. The latter process was applied to each one of the selected Landsat satellite images, all of which are freely available through Earth Explorer (https://earthexplorer.usgs.gov/). These multispectral Landsat images, with a spatial resolution of 30 meters, provided high accuracy in the processing, achieving accuracies exceeding 95% and resulting in comparable datasets. Satellite images obtained for each year were processed with image processing tools using the ArcGIS [21].

The types of the vegetation burned were derived from the Forest Inventory of Greece [22] and were calculated with spatial tools included in the GIS platform (Calculate Geometry tool). The term "forests" has been used when natural forest types were burned. The term "reforestations" was used when the vegetation burned was either patches of reforestations with alien species (for example, *Eucalyptus* spp.) or patches of reforestations with native species of other geographical distribution (e.g., *Pinus nigra*). The latter term has also been used in cases where isolated patches of *Quercus* species were burned. For calculating the total BA area per reporting period, we merged all polygons attributed to the different types of burned vegetation (Merge tool) and calculated the entire area that had been burned during this period. For providing the information on areas burned in fire intervals shorter than 15 years we intersected the given polygons with spatial tools included in the GIS platform (Intersect tool). These tools enabled us to estimate the types of the vegetation burned in such short intervals as well. Similar tools were also used for identifying the Natura 2000 sites which were affected by the fires during the entire period of study. The fire interval of 15 years was selected based on the critical time window necessary to ensure the natural post-fire recovery of *Pinus halepensis* [23], which represents the main forest vegetation type in the study area.

2.3. Statistical Analysis

To analyze the relationship between the number of fire events per year and the total burned area, we calculated the Pearson's correlation coefficient between the two variables and then we fitted several regression models, choosing the one with the lower Akaike information criterion (AIC) [24] values, indicating a better fit to the data. In order to interpret the variability in the BA, we used climatic data derived from the National Observatory of Athens, for Thision station (https://www.iersd.noa.gr/WeatherOnLine/s_Thiseio/meteo_tableEN.html, accessed on 5 November 2024), and population data derived from the Population-Housing Census conducted by the Hellenic Statistical Authority.

To investigate the relationship between burned area (BA) and various climatic and ecological factors, we used 13 predictor variables. The majority of these were meteorological factors, including annual mean temperature (Tmean), annual maximum temperature (Tmax), annual minimum temperature (Tmin), total annual precipitation (Prec), relative humidity (RH), mean temperature during the fire season (Tmean FS), total precipitation during the fire season (Prec FS), relative humidity during the fire season (RH FS), number of days with temperatures above 37 °C, number of days with temperatures above 40 °C (to represent extremely hot days) [25], and the maximum temperatures for July and August, representing the two hottest months for the period 1977–2024 and the months when most of the wildfires took place [26]. We also included population data derived from the Population-Housing Census to assess its potential impact on BA. Table 2 presents the 13 predictor variables used in the analysis across the six consecutive mapping periods.

Table 2. Predictor variables used to interpret the annual trend in the burned areas for the six consecutive mapping periods.

Period of Analysis	BA (ha)	No of Fires	Population	Tmean	Tmax	Tmin	RH	Prec	No Days Tmax > 37	No Days Tmax > 40	Tmean FS	Prec FS	RH FS	Tmax 7	Tmax 8
1977–1979	7320	11	2,797,849	17.85	22.55	14.30	62.71	379.33	3.33	0.33	23.20	108.07	55.24	32.89	32.11
1980–1989	33,754	30	3,312,267	17.57	22.68	13.76	62.64	355.24	3.40	1.10	23.39	71.88	55.19	33.20	32.90
1990–1999	31,612	28	3,508,009	17.92	22.92	14.36	62.19	395.60	6.00	0.40	23.99	83.03	54.69	33.65	33.50
2000–2009	36,691	14	3,737,970	18.59	23.39	15.06	63.23	462.22	11.70	1.60	24.75	134.12	55.68	34.78	34.56
2010–2019	18,630	15	3,784,828	19.10	23.72	15.69	58.89	426.85	10.20	1.40	24.99	113.37	51.72	34.55	34.63
2020–2024	54,037	10	3,808,729	21.06	24.62	17.31	57.09	321.92	12.40	3.60	27.38	125.24	50.69	33.95	32.89

The analysis was conducted on an annual basis. Among the available generalized linear models (GLMs), we selected a gamma distribution model, as our response variable (BA) was continuous and right-skewed. After checking for multicollinearity among the predictor variables, we initially tested all 13 predictors. We then simplified the model to minimize the Akaike information criterion (AIC) value. Finally, we calculated the mean fire interval (MFI) for the 10 distinct mountain ranges in Attica, where repeated fire events occurred over the 47-year study period from 1977 to 2024 (Table S1 in Supplementary Materials). All statistical analysis and data visualizations were performed in R [27], using the following packages: car [28], dplyr [29], e1071 [30], ggplot2 [31], ggpubr [32], and MASS [33].

3. Results

3.1. Fire Events and Burned Area

A total of 108 fire events were recorded during the 47-year analysis period from 1977 to 2024 (Table S1, Supplementary Materials). The number of fire events per year varied from 0 to 6, while the mean annual burned area was 3,792.6 ha. The largest burned area occurred in 2021, with four distinct fire events resulting in a total of 24,275.8 ha burned. The Pearson correlation coefficient between the number of fires and the total burned area on an annual scale was 0.478, indicating a moderate and statistically significant positive correlation ($t = 3.6957$, $df = 46$, p-value = 0.0005818). Several generalized linear models (GLMs) were tested, with the GLM using the gamma family yielding the lowest AIC value of 746.69. This model suggests that each additional fire event is associated with a 58% increase in burned area (Figure 1, Table 3).

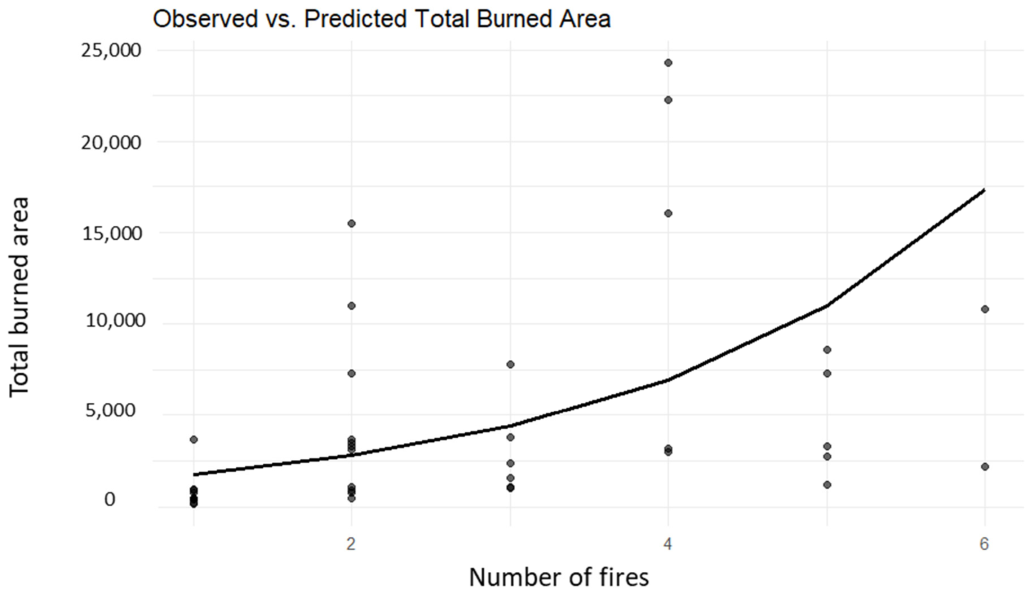

Figure 1. Comparison of observed versus predicted total burned area in relation to the number of fires, using the generalized linear model (GLM) with the gamma family.

Table 3. Results of the GLM with the gamma family. *p*-Values lower than 0.05 indicate a statistically significant effect of the predictor variable (***: $p < 0.001$, **: $p < 0.01$).

Model	Coefficient	Std. Error	t-Value	*p*-Value
Gamma GLM				
Intercept	70.166	0.4000	17.542	$<2 \times 10^{-16}$ ***
No_of_fires	0.4576	0.1288	3.554	0.00103 **
Model Fit Statistics				
AIC	746.69			
Null Deviance	60.593			
Residual Deviance	46.912			
Dispersion Parameter	15.651			

Regardless of the number of fires per year, as we approach the present the BAs are increasing. Figure 2 represents the area burned for the six distinct periods used in the current study for mapping the BA in Attica Prefecture. The total BA for the period 2010–2019 was relatively low, although the climatic parameters did not differ significantly compared to the other five distinct periods (Table 2). According to the data derived from the Copernicus EFFIS program for Greece, covering the period 2006–2020, the year 2012 with 52,487 ha burned was the second worst year in terms of the total BA after 2007 (271,715 ha), and the third in terms of the total number of fires, after 2007 and 2020 (139 and 88, respectively).

Figure 3 presents the spatial distribution of the total burned areas (BAs) in Attica, along with the areas burned multiple times. The total BA corresponds to 182,086.8 ha. Given that the area of Attica Prefecture is 380,800 ha, the area burned during the study period represents nearly half of the area of the prefecture (47.82%). Attica experiences frequent wildfires, but the fire frequency varies across the different parts of the prefecture. Out of the total of 108 recorded fire events, 78 were either exclusively or primarily located in the main mountain ranges. Among these, both the number of fires and the fire interval differed, varying from 2.5 years in lower hills such as Mt. Merenta to 18.5 years in Mt. Kitheron. However, elevation does not fully explain the MFI, as Attica's highest and largest mountain, Mt. Parnitha, is frequently burned, with an MFI of 4 years (Figure 4). Fire incidents did not typically occur on recently burned areas, providing further support for the use of a time window of 15 years to identify areas burned twice or more. The variation observed in the mean fire interval across mountains appears to be influenced by the dominant vegetation, with more frequent fires occurring in mountains that still host *Pinus halepensis* forests (see next paragraph), such as the foothills of Mt. Parnitha.

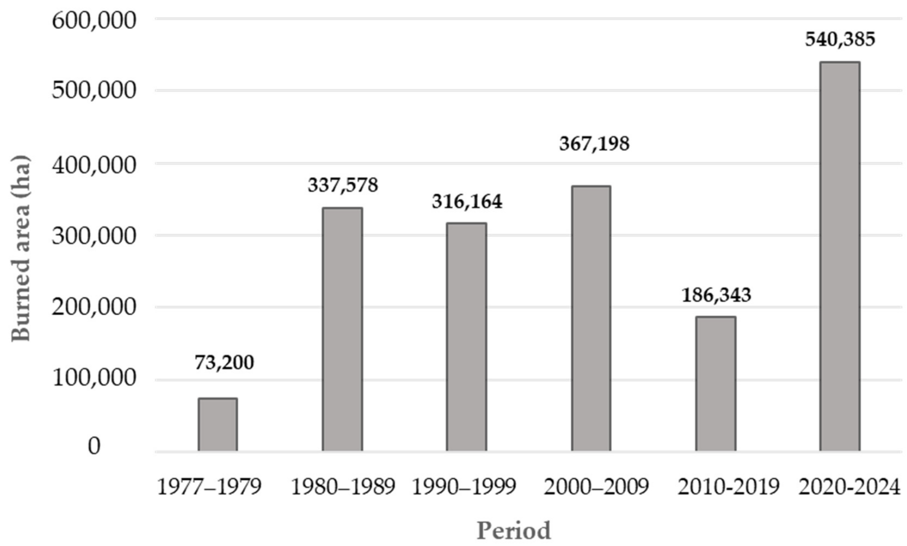

Figure 2. Area burned in Attica during the study period (1977–2024). Only fire events larger than 150 hectares are included.

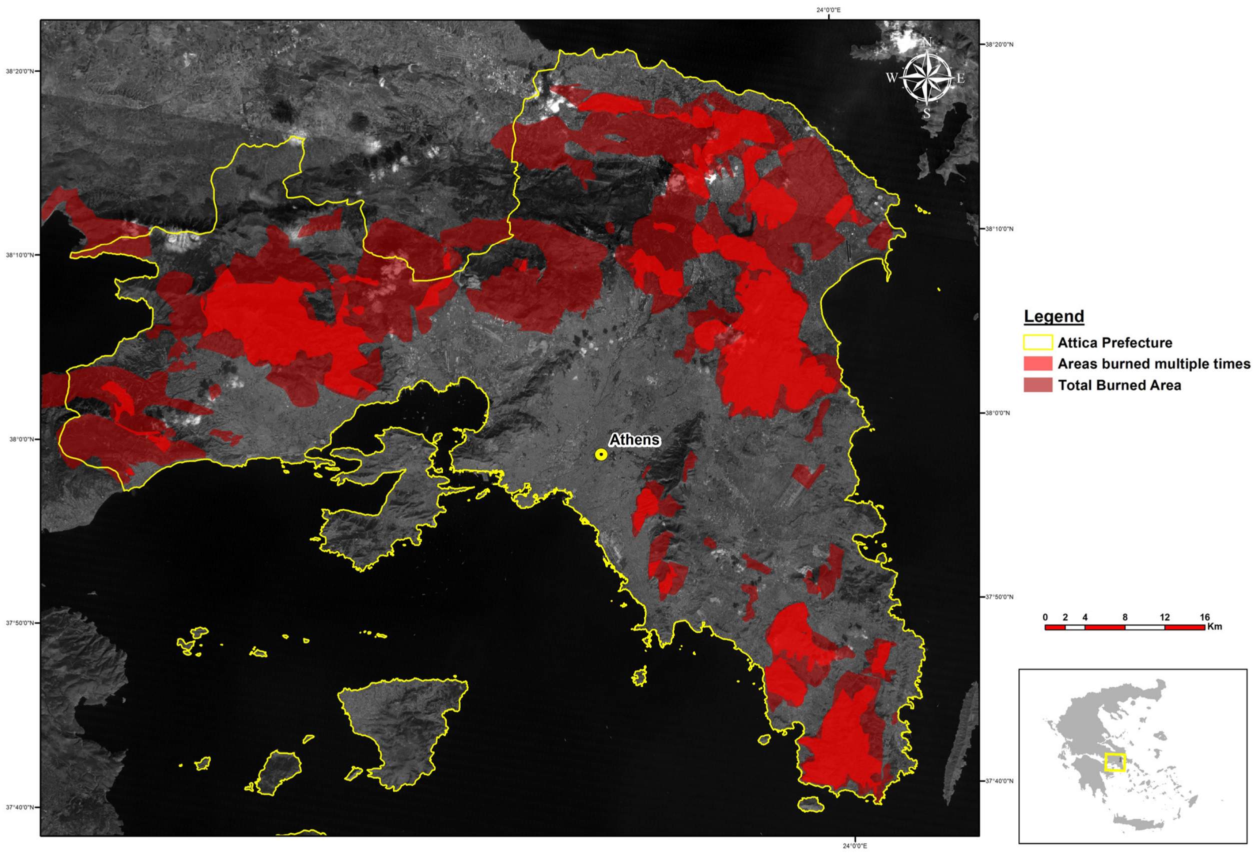

Figure 3. Delineation of the burned areas in Attica Prefecture over the entire study period, along with the areas burned multiple times. Only fires larger than 150 hectares are included. Data Sources: Landsat 8 / USGS, RGB: Gray Scale. Resolution: 30 m. https://earthexplorer.usgs.gov/.

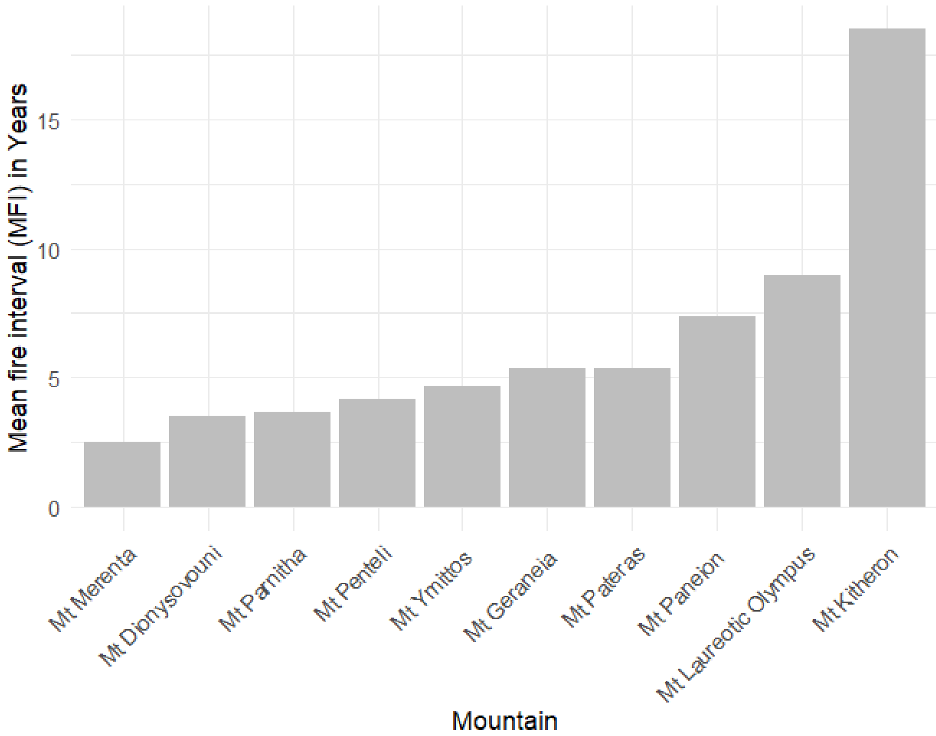

Figure 4. Mean fire interval per mountain range for the period 1977–2024.

Details about the extent of areas burned per year within each period as well as their spatial configuration can be found in the Supplementary Figures S1–S6.

3.2. Vegetation Burned

Figure 5 represents the vegetation types burned during the period of study. The vegetation burned was mostly *Pinus halepensis* forests, which is justified by the fact that forest vegetation of Attica primarily consists of this type of Mediterranean forests. Yet the 2007 wildfire in the Mt Parnitha National Park consumed 1971 ha of *Abies cephalonica* forests. Since then, several fire events have burst over fir forests in Attica. Fir forests grow on altitudes higher than Aleppo pine, usually from 1000 m and higher, in the mountains located in the north and northwest part of the prefecture. In total, during the period 1977–2023, 45% of the BA was covered with *Pinus halepensis* forests, 18.5% with shrublands, 1.4% with *Abies cephalonica,* and another 10% with other vegetation types.

During the 1st period of study (1977–1979), 60% of the BA was covered by Aleppo pine forest and 30% by shrublands (Figure S7). Similarly, 70% of the BA in the 1980–1989 period was Aleppo pine forest and 20% shrublands. The relative contribution of Aleppo pine forests to the BA remains consistently high for all examined periods, 65% for 1990–1999, 50% for 2000–2009, 55% for 2010–2019, and 65% for 2020–2024 (see Figures S8–S12).

The fact that 45% of the total BA corresponds to *P. halepensis* forests implies that several areas should have been burned multiple times. Indeed, 65% of the reburned area during the entire study period was covered with *Pinus halepensis*, 25% with shrubs, and 1.2% with *Abies cephalonica* (Figure 6).

Several parts of the burned mountainous regions fall within protected areas belonging to the Natura 2000 network. Figure 7 depicts the areas designated as Natura 2000 sites in Attica as compared to the total BA over the entire study period.

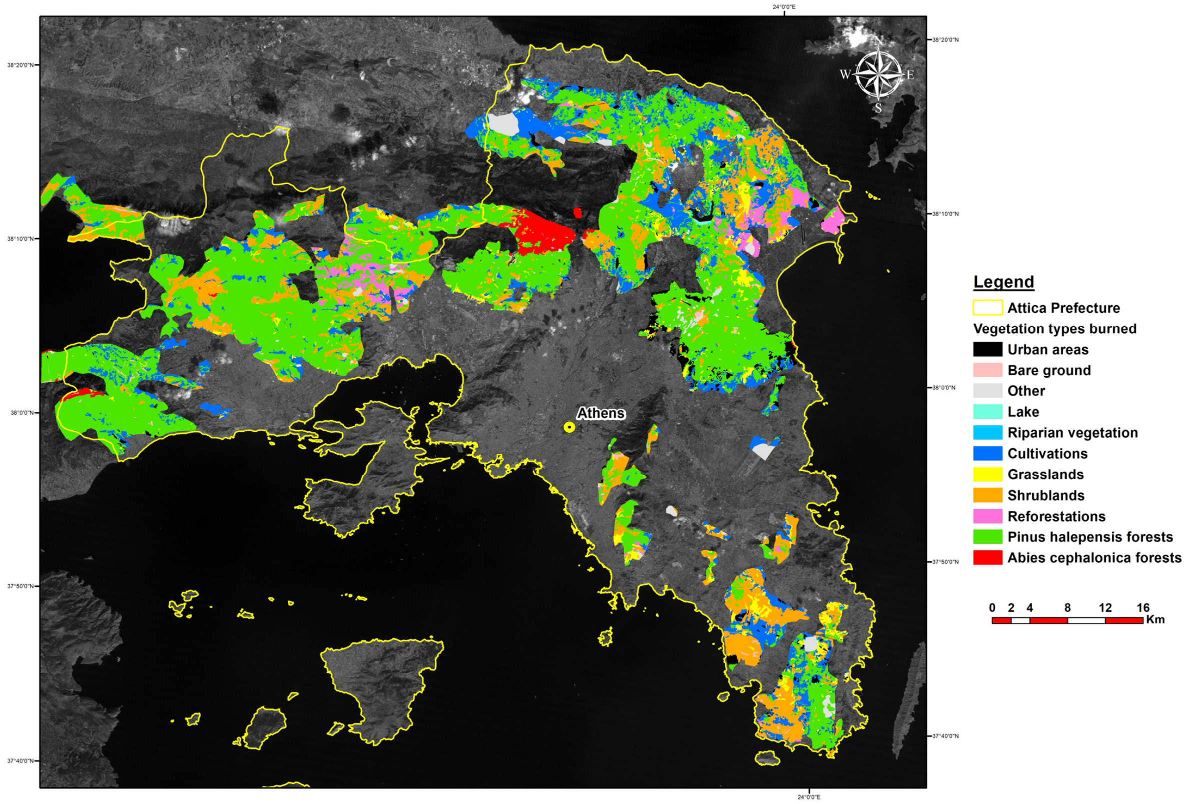

Figure 5. Total vegetation burned across the study period (1977–2024). Data Sources: Landsat 8/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/.

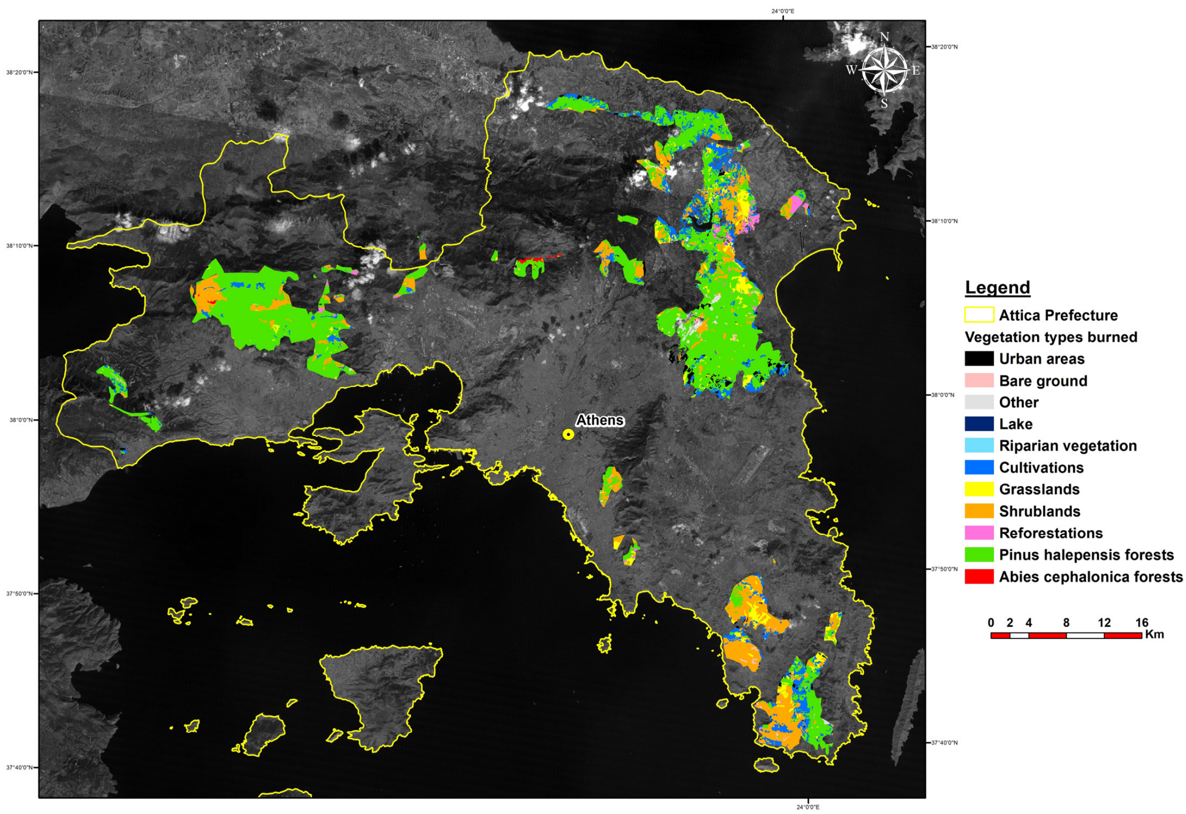

Figure 6. Areas burned at least twice during the fire interval of 15 years and vegetation types burned. Data sources: Landsat-2, 8/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/.

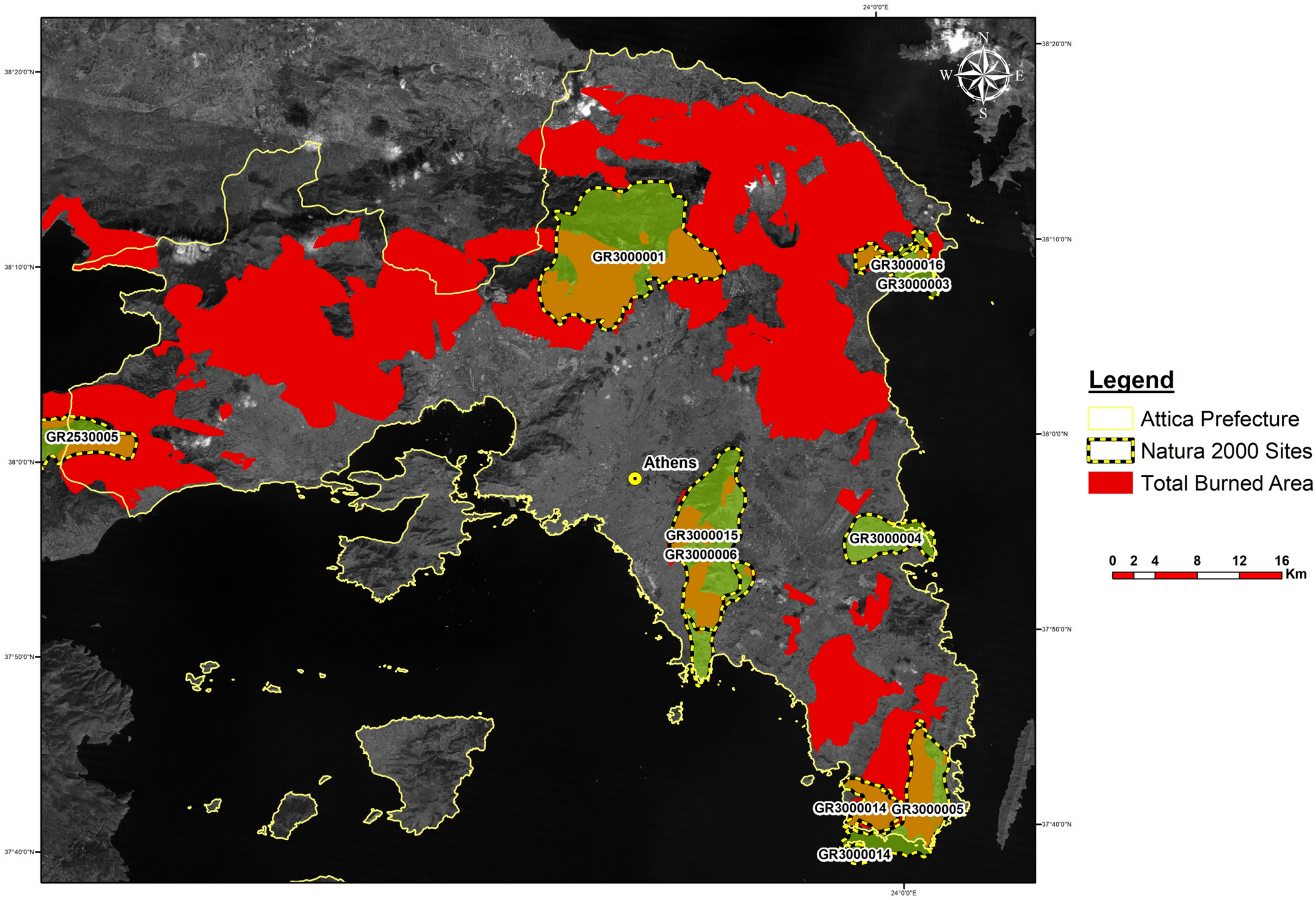

Figure 7. Areas designated as Natura 2000 sites in Attica Prefecture, depicted over the total BA during the study period. Landsat-2, 9/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/.

Natura 2000 sites in Attica cover an area of 40,340 ha, a great portion of which was burned during the study period, amounting to 15,447 ha, a percentage of 38.9% (Figure 8). This is important both for the total area burned but also for the protected habitats and species that might have been affected by the wildfires.

3.3. Relationship Between BA, Meteorological, and Ecological Factors

The gamma GLM that best described the relationship between BA and the tested meteorological and ecological factors (AIC = 267.83) included 7 of the 13 initially tested predictors and had a dispersion parameter of 0.451. Of these predictors, only relative humidity (RH) was statistically significant ($p = 0.0321$), indicating that wetter conditions are less conducive to fires. Annual precipitation, while not significant at the 0.05 level, showed a marginally significant negative relationship with BA ($p = 0.0841$), suggesting that increased precipitation could help reducing the extent of wildfire. The remaining predictors did not show significant correlations with BA (Table 4).

Table 4. Coefficients of the optimal model (simplified GLM with a gamma distribution) predicting annual burned area as a function of climatic and ecological variables. *p*-Values lower than 0.05 indicate a statistically significant effect of the predictor variable (***: $p < 0.001$, *: $p < 0.05$).

Predictor	**Estimate**	**Standard Error**	***p*-Value**
Intercept	1.79392	0.09694	2×10^{-16} ***
Population	−0.16890	0.13359	0.2134
Precipitation during the fire season	−0.10597	0.12639	0.4068
Precipitation	−0.24205	0.13662	0.0841.
Tmax	0.04996	0.15195	0.7440
Relative humidity	−0.27570	0.12414	0.0321 *
No of days with Tmax > 40	−0.11681	0.16647	0.4869
No of days with Tmax > 37	0.12221	0.17653	0.4928

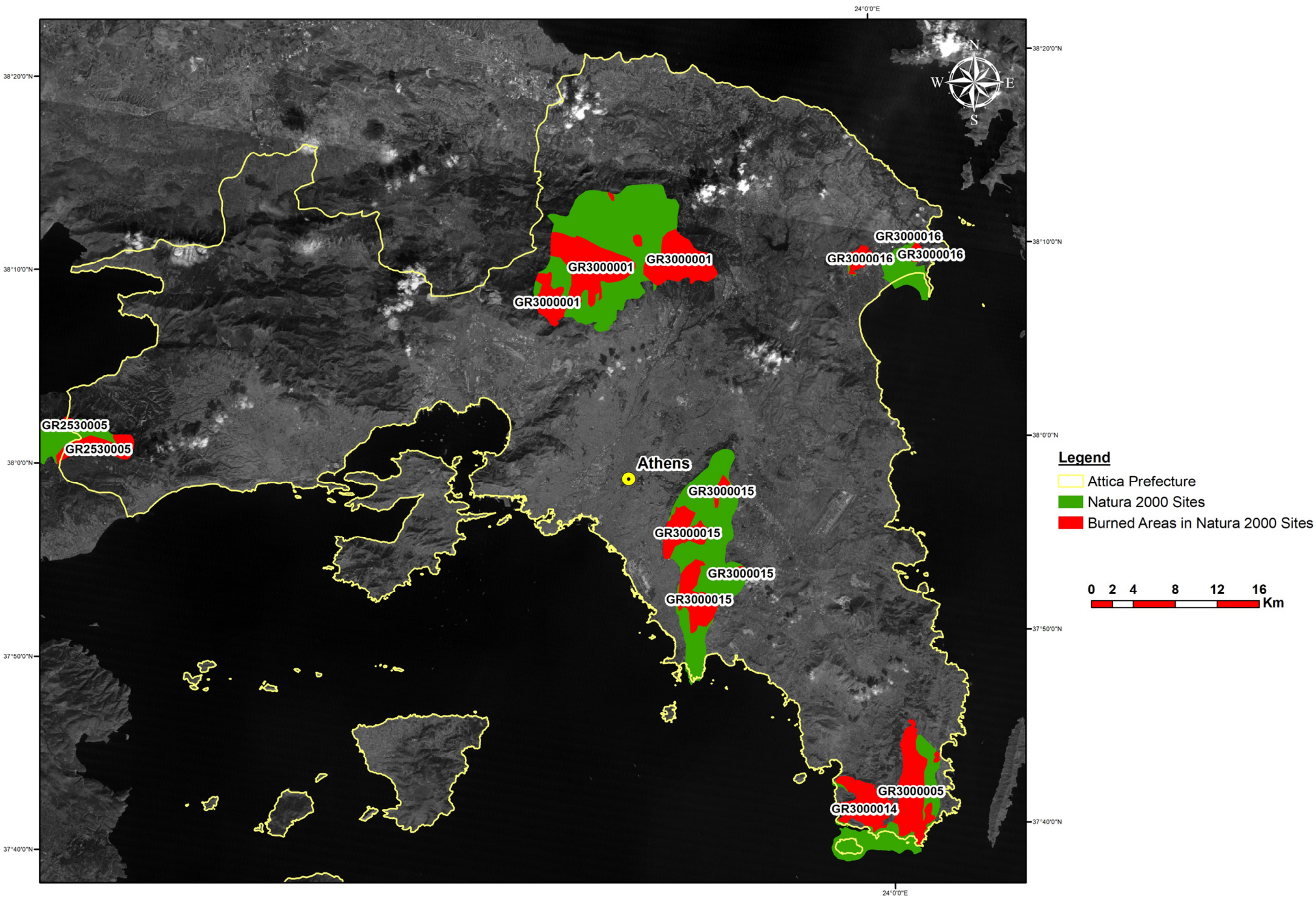

Figure 8. BAs within the Natura 2000 Network during the period 1997–2024. Landsat-2, 9/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/.

4. Discussion

Greece is one of the European countries with high fire hazard [34], and previous studies have identified Attica as one of the regions exposed to the highest fire risk [35]. Forest fires in Greece occur mainly in middle and low latitudes, as Kontoes et al. [15] reported for the period 1984–2021. During this period, the total BA for Attica was 108,072.32 ha, representing 28% of its total area and 12.3% of the areas burned in the entire country [10].

The years with the more severe events were those of 2000, 2007, and 2021 in which 85,015, 199,004 and 118,540 ha were burned, respectively, in the entire country, with the southern and more arid regions of the country showing greater susceptibility to wildfires than the northern and wetter regions [15]. Our results are in accordance with these findings, since 171,114 ha were burned during the study period of 1977–2024, while the periods with the most severe wildfires were those of 2000–2009 and 2020–2024 in which 36,719 and 54,038 ha were burned, respectively, only in Attica. The total burned area for the period 2010–2019 was relatively low, although the climatic parameters did not differ significantly compared to the other five distinct periods. In contrast, in the rest of the country some devastating wildfires took place, as was the case of the wildfire in Chios in 2012, when more than 14,800 ha were burned [36].

Both the total number of recorded fires (108 fire events during the 47-year analysis period) and the extent of burned areas highlight the pressure on the ecosystems of Attica. BA is negatively correlated with relative humidity, while reduced precipitation may contribute to the expansion of wildfires. Weather is considered as an important factor controlling fire occurrence in Greece [37,38], especially in the years with extreme drought conditions [39,40]. The climate of Attica is characterized by an extended xerothermic period of approximately five months. This period is critical for drying out the vegetation which is thus susceptible to fires. Based on climatic data obtained from the National Observatory of Athens covering the period between 1900–2020, an increase in the mean annual temperature of 2 °C was detected. This could be one of the reasons why there is an increasing trend of the BAs towards the present (Figure 3). This trend in wildfires seems to be related to the increasing trend in the mean annual temperature recorded since the 1970s and becoming more apparent particularly since 2010, with 2022 representing the only year up to present when the mean annual temperature in Attica exceeded the 23 °C. The same trend has been also reported by Kontoes et al. [15], and has been attributed to the same factor. The positive correlation between the number of fire events per year and the total burned area may also indicate a challenge in dealing with multiple, simultaneous fire incidents [41], which is something to be taken into account at the operational level.

However, other factors could also be behind the increasing number of fires larger than 150 ha in Attica. Attica is the Prefecture of Greece that is the most densely inhabited area, inhabited by nearly half of the country's population, and where urban expansion often occurs at the expense of forested or shrubland areas [11,12]. Although no correlation was found in the current study between the total population size and the BA, there is an intense pressure coming from the expansion of cities and the economic activity in the nearby peri-urban areas, as has been reported in other studies [8]. Minetos and Polyzos [42] stated that the increased demand of land for urbanization and infrastructure is one of the most powerful drivers of forest fires in Greece. It is true that between 1971 and 2021 the population of Attica Prefecture increased from 2,740,588 to 3,814,064 inhabitants (census data from the Hellenic Statistical Authority), an increase of 39.17%. This increase was remarkably high in the East Attica Prefecture Unit, in which inhabitants rose from 131,836 to 518,755 between 1971 and 2021, an increase of 294%. Similarly, the population of the West Attica Prefecture Unit rose from 68,560 to 165,540 for the same period, an increase of 141.45% (census data from the Hellenic Statistical Authority). These two prefecture units concentrate most of the fire events recorded during the study period. The spatial planning system of Greece proved to be inadequate in containing the urban expansion of several cities [43,44] while, as Briassoulis [45] found, the construction activity observed in those decades was positively correlated with the number of forest fires in the area. Salvati and Ranalli [44] indicated that a significant increase in fire size occurred in the period 2008–2011 in Athens' peri-urban area, while fire size decreased in rural areas, which are actually rather quite sparse and through time have become even fewer in Attica.

As regards to the vegetation types burned, as expected, the majority of the BAs corresponded to Aleppo pine forests and shrublands, the two vegetation types covering the greatest part of Attica's area, 34% and 16%, respectively (data from the Forest Inventory), and representing the most fire-prone vegetation types. In total, these two types covered 99,000 ha and 45,240 ha, respectively. In these areas, 73% of *Pinus halepensis* forests and 64% of the shrublands have been burned during the study period. In Mediterranean areas shrublands, grasslands, and coniferous forest are found to be more fire prone than croplands and broadleaf forests [4,46,47]. This is mainly due to the more xeric conditions in which these ecosystems are found but also to the type of fuel they form. Low-altitude Aleppo pine forests usually support crown fires [48] and because of the spotting (cones dispersal over long distances), most of the fires spread rather quickly. Aleppo pine forests usually sustain a great amount of dead standing biomass, while litter is composed by dried needles and branches [49]. Regarding the shrublands, they also form thick litter layer of fallen leaves and twigs, which decomposes very slowly [50], while they are very densely arranged, sustaining medium-intensity fires [49]. The importance of the Mediterranean vegetation in the initiation and spread of forest fires results from its capacity to sustain fire ignition and subsequently allows the spread of fire by providing it with the necessary fuel in such spatial arrangement and quality that allows it to produce the highest energy release per surface unit compared to other vegetation types [51,52]. *Abies cephalonica* forests grow in higher altitudes than Aleppo pine forests and shrublands and they form a close canopy with sparse understory shrubs. Most of the fuel consists of fallen dead woody remains and needles or leaves as litter. Fire risk in these forests is generally low as they receive higher precipitation in the form of rain or/and snow during the winter months. However, fire risk in fir forests is increasing when the stands grow older, through the accumulation of dead logs and branches on the soil as a result of damage from snow, windthrows, mortality caused by insects, etc. Natural ignitions due to lightning are an important cause of fire, but upslope-wind head fires from forests of a lower altitude can also burn these ecosystems, as happened in the case of Mt Parnitha National Park during the catastrophic fire of 2007 [49], in which almost 50% of the total cover of fir forest of the National Park was burned [53]. The same year extensive wildfires were recorded in the fir forests of Southern Greece (Peloponnese) [54], causing the concern that these forests may be further endangered in the future due to climate change and increased aridity. The accumulation of fuel due to land abandonment and the source of ignition, often caused by arson, increase the exposure of fir forests to fire risk [55].

A remarkable area of 44,050 ha has been reburned multiple times with a fire interval less than 15 years. This tendency of fires to initiate and spread over the same areas has been also reported by [15] for the period 1984–2021 for the entire country. The fire interval of 15 years has been selected based on the time window needed for the most severely affected Aleppo pine forests to avoid immaturity risk [56]. Fifteen to twenty years are needed to reach maturity and to produce a sufficient canopy seed bank from which its natural regeneration will be ensured in the case of another fire event [23]. Indeed, this is critical since 60% of the reburned area corresponds to Aleppo pine forests. The high fire frequency estimated for the main mountainous areas of Attica might imply a short fire interval in several cases, which could consequently lead to substantial land cover change. There are several examples of *P. halepensis* forests, such as those on Mt Penteli, that have already been converted either to shrublands due to frequent fires and/or to built-up areas [11]. The interval between successive fires in the mountainous areas of Attica ranges from 2.5 to 18.5 years. The mean fire interval (MFI) is the average number of years between fire dates and has been widely used to describe fire frequency [57]. In the regions of the Mediterranean Climate Biome, MFI usually refers to events occurring naturally [58,59]. The MFI of 6 years found for the mountainous areas of Attica is below the estimated natural fire frequency for the five Mediterranean-type climate regions of the world [58,59], but since many fire events of the reporting period have not been attributed to natural causes no actual comparison can be attempted. In cases of short fire intervals, potential lack of post-fire regeneration or vegetation conversion are not the only environmental factors that need to be considered. Post-fire soil erosion also becomes more probable in the case of multiple fires taking place on the same sites because of the difficulties in the recovery of vegetation which could protect the soil from erosion (e.g., [60,61]).

Of special interest are the BAs falling within the borders of the Natura 2000 Network, since they host protected habitats and species of European concern, together with endangered species. As previously stated, 39% of the Natura 2000 sites in the mainland of Attica Prefecture have been burned during the past 46 years (1977–2024). Mt Ymittos (GR3000006) and Mt Parnitha (GR3000001) have been affected more than the other Natura 2000 sites of Attica, with 14 and 10 fire events, respectively.

The importance of wildfires burning in Natura 2000 sites has been realized at the European level. Several reports have been published by the Joint Research Center (JRC) for a series of years. For example, JRC issued the publication *EU Forest Fires in Europe* [62], in which the number of fires which have occurred in Natura 2000 sites per country of the European Union are reported, together with the area burned. Greece is listed among the top countries with the largest area burned after Spain, Portugal, and Italy. According to San-Miguel-Ayanz et al. [63], for the period 2000–2012 the total area of the Natura 2000 protected areas burned in the five southern Mediterranean countries (France, Greece, Italy, Portugal, Spain) was 1,044,917 ha, corresponding to 3.28% of the total Natura 2000 area in the affected countries. In Greece, an area ranging from 0 (in 2003) to 38,192 ha (in 2007) has been burned during the study period, with the total BA corresponding to 99,473 ha or 2.8% of the total Natura 2000 sites of the country. The year of 2007 was the worst of all with 139 fire events all over the country and 271,715 burned ha. The BAs comprised several Natura 2000 sites, including the Mt Parnitha National Park (GR3000001). Since this fire affected a large part of the strictly protected area and almost 50% of the endemic *A. cephalonica* forest, several studies have been conducted to monitor the natural regeneration and the effectiveness of the restoration practices (e.g., [53,64,65]). The acquired knowledge from this fire event is important since more fires have been recorded around the fir forest of Mt Parnitha, as well as in other fir forests of Attica, during the past few years and information on how to deal with their protection and post-fire management is needed.

5. Conclusions

The data provided in this paper confirm that climatic parameters are very much affecting the occurrence of forest fires in Attica, a typical Mediterranean region which has experienced an uncontrolled urban sprawl during recent decades. Changing climate is expected to create more severe conditions in the future, which could prove uncontrollable unless serious mitigation and adaptations measures are planned and put in force immediately. Studying the long-term patterns of forest fires is of highest priority for Mediterranean regions like Attica to protect the citizens but also to secure the existence of the last remaining forests in a very densely populated area.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/fire7120467/s1, Table S1: Fire events and burned area in hectares (ha) per year and per mountain and its broader area. Only fire events larger than 150 hectares are included, Figure S1: Areas burned in Attica Prefecture during the period 1977–1979. Fires larger than 150 hectares are considered. Data sources: Landsat-2, 9/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/, Figure S2: Areas burned in Attica Prefecture during the period 1980–1989. Fires larger than 150 hectares are considered. Data sources: Landsat-5/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/. Figure S3: Areas burned in Attica Prefecture during the period 1990–1998. Fires larger than 150 hectares are considered. Data sources: Landsat-5/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/, Figure S4: Areas burned in Attica Prefecture during the period 2000–2009. Fires larger than 150 hectares are considered. Data sources: Landsat-5/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/, Figure S5: Areas burned in Attica Prefecture during the period 2010–2019. Fires larger than 150 hectares are considered. Data sources: Landsat 7–8/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/, Figure S6: Areas burned in Attica Prefecture during the period 2020–2023. Fires larger than 150 hectares are considered. No fires have occurred during 2020. Data sources: Landsat 8–9/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/, Figure S7: Vegetation types burned in Attica Prefecture during the period 1977–1979. Data sources: Landsat-2/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/, Figure S8: Vegetation types burned in Attica Prefecture during the period 1980–1989. Data sources: Landsat-5/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/, Figure S9: Vegetation types burned in Attica Prefecture during the period 1990–1999. Data sources: Landsat-2/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/, Figure S10: Vegetation types burned in Attica Prefecture during the period 2000–2009. Data sources: Landsat 5–7/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/, Figure S11: Vegetation types burned in Attica Prefecture during the period 2010–2019. Data sources: Landsat 5–8/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/, Figure S12: Vegetation types burned in Attica Prefecture during the period 2020–2024. Data sources: Landsat 8–9/USGS, RGB: Gray Scale, Resolution: 30 m. https://earthexplorer.usgs.gov/.

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