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Forest fires in the Lazio region: governance initiatives and good practice

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Abstract

From being an instrument used by man to manage his ecosystems and own life, fires have become a "social aggression". Fresh outbreaks have been occurring for years now in woodland areas but not only. The Lazio region (Italy) represents a peculiar case, occupying fourth position in the national ranking of the regions most greatly hit by fires. Arson has been found to be the cause in most of these cases. Interactive cartographies or cartograms, put together with the data obtained from the Civil Protection and ISTAT, have made it possible to outline the trend of the last twenty years for the five provinces of Lazio and the predisposing factors. The proper use of these instruments is proving to be increasingly fruitful in understanding the devastating consequences of the upsurge of outbreaks of fire and to assist the stakeholders in the identification of more efficient planning, government initiatives and good practice. This paper highlights the educational impact of the use of such technologies and the identification of interventions for the forecasting, prevention and active fight against this phenomenon, with the aid of the Forest firefighting Plan (drawn up by the region) and the lQ (framework law) 353/2000, in order to achieve positive results, considering that the actions put into place so far have not given appreciable results.

Keywords: Fires, Good Practice, Governance, Lazio Region

1. The phenomenon of forest fires as an environmental problem

This paper deals with the phenomenon of forest fires in the Lazio region, in Italy, the environmental issues linked to such events and, with specific reference to real situation being taken into consideration, the framework of measures adopted to tackle them.

We often find ourselves powerless before the degradation of the environment and landscapes (natural, rural or urban). In the case of the damage caused by wildfires, the consequent environmental degradation can rarely be defined as being accidental or fortuitous, due to unextinguished embers, sparks caused by electricity cables blown down by summer storms

or given off by rails in the presence of dry plant material on the ground, gas leaks etc.

Research and judgments (Tulumello et al., 2018; Lovreglio et al., 2012) show that most of these cases are due to arson[1], wilful or culpable, owing to unforgiveable acts of carelessness, negligence, lack of attention, ignorance or an underestimation of the risk for health and the environment. It is the work of "barbarians", the authors of criminal actions carried out for personal gain for third parties, for which society will pay an extremely high price and for a long time to come (Brugger, 2007; Pyne et al., 1996): this is the case of the destruction of woods, agricultural areas and buildings. While in many cases it is possible to replace woods and other artefacts, it is not possible to give back life or part of the biodiversity.

Forest fires have become a "social aggression" towards that very nature which should be protected insofar as the giver of essential services, conservation of the soil, production of timber, purification of water and land, accumulation of carbon, aesthetic and touristic aspects and the capacity to offer relaxation and recreation. The causes also seem to be traced back to numerous socio-economic problems linked to the improvement of living conditions: the depopulation of vast rural areas, the abandoning of farming, the distribution of new settlements in the countryside environment, the spread of transport infrastructures etc. are all changes that have led to the rise of interests often in conflict with the conservation of the natural resources (Blasi et al., 2004).

Forest fires are a recurrent phenomenon, not subject to great margins of variability, unless for what concerns the number of outbreaks or the areas involved. According to the *World Economic Forum*, global warming and climate change are making the conditions more widespread and easier for the flames to flare up. Any definition of the damage deriving from the fires or an evaluation of the danger is far from easy as international reference standards do not exist (Viegas et al., 2000; Cosens et al., 2014).

It thus becomes indispensable to revaluate and improve the current legislation and preventive measures, management and planning: above all to depart from a greater awareness of the phenomenon and consequent risks, drawing up informed policies on risk and good practice (Marchetti and Pettenella, 1994); not least, entrust the studies for each single complex system devastated by the fires to multidisciplinary competences, so that each one is characterised for its different physical, biological, cultural and social elements. Lastly, set up an organic interventions plan, based on the knowledge of the motivations and aimed at acting on the causes, rather than mitigating the consequences of the fires, considering the fire as the final act of a complex interaction of predisposing factors (environmental, climatic and vegetational conditions) and determining causes (high potential heat input that triggers the fire) (Blasi et al., 2004). A systemic approach is therefore vital, with the support of GIS technology (Chen et al., 2003; Favretto, 2012), thanks to its particular but powerful language (Dangermond and Pesaresi, 2018).

2. Forest fires in Lazio

In the Lazio region, an area situated in the centre of the Italian peninsula between the upper part of the Elvella torrent and the Gaeta promontory, the forest fires have increased exponentially in the last twenty years. This region is in fourth place in the national ranking for surface area destroyed by fire, behind Sicily, Calabria and Campania (Istat, 2018).

2017, defined as the *annus horribilis* at national level, was the most devastating with 19,318 hectares of forest area swept by fires for a total of 548, mostly between May and August (Istat, 2018).

[1] According to the classification of the State Forestry Corps (CFS), they are: to gain profit (for construction of arable land and pasture or to set up the *set-aside*; for the cleaning of land of agricultural waste; for building in particularly attractive areas; for the creation of jobs in relation to the activities of recovery and extinguishing; to profit from insurance policies – also outside the forests); not to make actual profit (out of resentment or protests – also outside the woods; for acts of vandalism), for pathological reasons (by pyromaniacs).

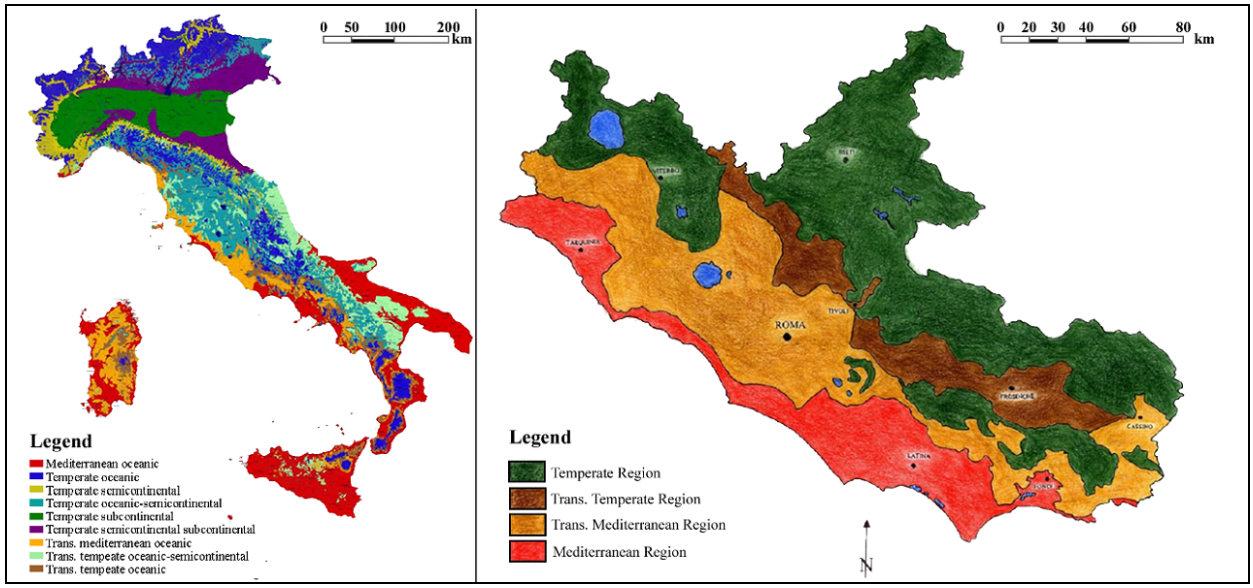


Figure 1. Map of the phytoclimate in Italy and Lazio-synthesis.
Source: Author's elaboration by Blasi, 1994; Regione Lazio, 2011.

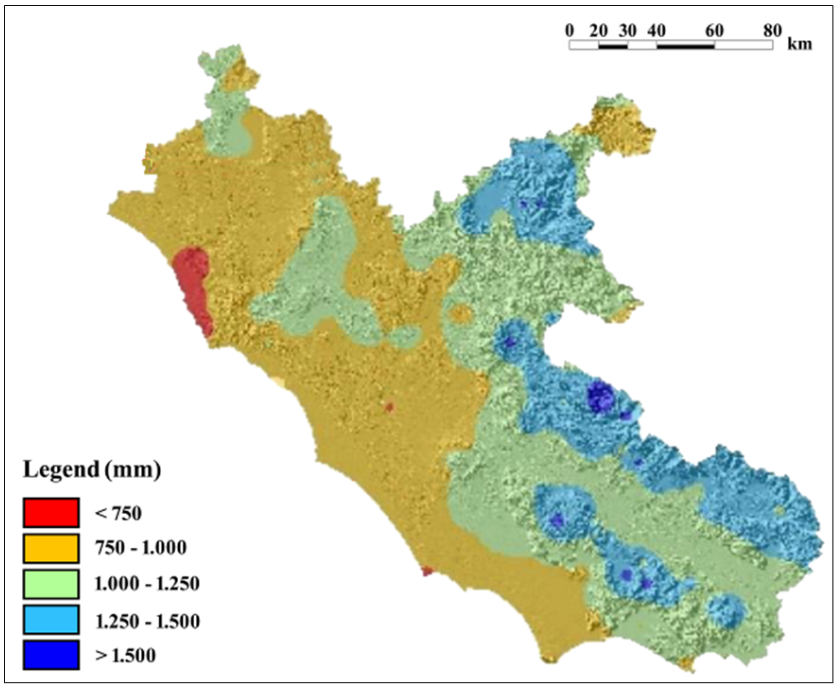


Figure 2. Pluviometric map of Lazio 2017. Source: meteomarta.altervista.org
[Meteorological and climatological center in Marta municipalities (Viterbo province)].

Every year the phenomenon is considerably widespread in the summer period, as it is hot and droughty and the vegetation is dormant, in a Mediterranean climate, as is the case in the remaining centre-south area (Figures 1-4)[2].

[2] Lazio is characterised by four phytoclimatic regions with meteorological conditions that are quite

In the northern areas of the Alpine arc and in the high altitude Apennine areas, the fires develop mostly in the winter-spring season during vegetative rest and the rainfall is less abundant, and with quite strong winds which aid the spread of flames. Exceptions do exist in which the frequency is distributed during the whole year, since the fires often start in urban contexts, close to rubbish dumps or industrial areas, owing to gas leaks, fires in waste bins or means of transport.

The rising regional trend can be clearly seen from the data analysis[3] (Figure 5): in 1997, 7,414 hectares were covered by fire for a total of 739 blazes, in 2007, 13,567 hectares in 831 fires. The trend was nonetheless sinusoidal, linked to the alternating of "serious" events in some years per area concerned and number, and better times. In the last seven years, in particular, the following stand out: 2011 for strong intensity, with 6,877 hectares for 661 infringements and 2012, with 8,066 hectares for 715 fires; for minimum values the two years 2013-2014, with respectively 1,393 and 1,148 hectares for 198 and 212 forest fires. The trend for the years 2008, 2009 and 2010 is medium-low, with 2,669, 2,528 and 3,152 hectares for a total of 370, 324 and 354 fires, which ranked the region between seventh and sixth place in Italy; the trend for the two years 2015-2016 was medium-high, with 5,947 and 3,925 hectares for 354 and 456 infringements. By looking at the distribution per province, Latina (municipalities of Itri, Formia and Fondi) and Frosinone (municipalities of Esperia, Vallecorsa, Cervaro, Colle S. Magno) stand out in the last seven years almost exclusively for the area involved and the number of infringements; Rome (municipalities of Rome and Roviano) per area concerned in the years 2012 and 2016 (Figures 6-13).

The traceability of the distribution over the year to the climate orientation, on which the fire phenomenon tends to be modelled, is confirmed by the fires during the 2011-2012 period, more intense between April and June-October owing to low rainfall and very high temperatures (Figures 3-5).

In the twenty-one years, from 1997 to 2017, the surface area affected by fire totalled 117,295 hectares (equal to 19% of the whole regional forest area) for 9,454 forest fires, on average 5,585 hectares for a total of 450 infringements a year (Figure 5). This historical-statistical analysis, even though not making it possible to characterise the phenomenon of forest fires in Lazio in a precise and definitive way, also owing to the difficulty linked to the inhomogeneous nature of the data recorded by the various national and regional bodies involved, nevertheless helps to understand it.

homogenous: Mediterranean, Mediterranean transition, temperate transition, temperate. They are the synthesis of 15 phytoclimatic units obtained from the relationships between the climate (temperature and rainfall) and regional vegetation (Figure 1).
The climatic conditions of the region are influenced by its geographical position, altitude and exposure of slopes. Starting from the eastern part are to be found higher Apennine reliefs (calcareous) which run diagonally from N to S (Reatini, Sabini, Simbruini, Ernici) connecting up to the mountains of the Antiapennines (Lepini, Ausoni, Aurunci) parallel to the southern coast. The hilly areas, in part volcanic, (monti della Tolfa, Volsini, Cimini and Sabatini, Colli Albani), and the plains (Maremma Laziale, Campagna Romana, Agro Pontino, Piane di Fondi and del Garigliano) reach the Tyrrhenian coasts. Along the coastline the climate is maritime, tending to get colder in proximity of the mountain chains parallel with the coast. The hills and intermontane basins have cold winters passing to the mountain climate of the Apennines, with cool summers with storms. In the valleys and flatlands in summer the temperatures exceed 30°C. The rains are most abundant on the slopes exposed to the sea influenced by the damp winds coming from the Tyrrhenian sea, less heavy on the coastal flatlands (600-700 mm annually) and in the intermontane basins. They exceed 1500 mm annually on the Apennines, 1000 mm in the hills and in the Antiapennines (Figure 2). The rainiest periods are the autumn and spring, with a marked summer minimum. The meteo-climatic analysis was carried out in collaboration with the Consiglio per la Ricerca in agricoltura e l'analisi dell'Economia Agraria (CREA).

[3] For the data from 1997 to 2011, see Regione Lazio, 2011; for the data from 2012 to 2017, Istat, 2012-2018; Tulumello et al., 2018; Agenzia Regionale Protezione Civile – ARPC, 2018.

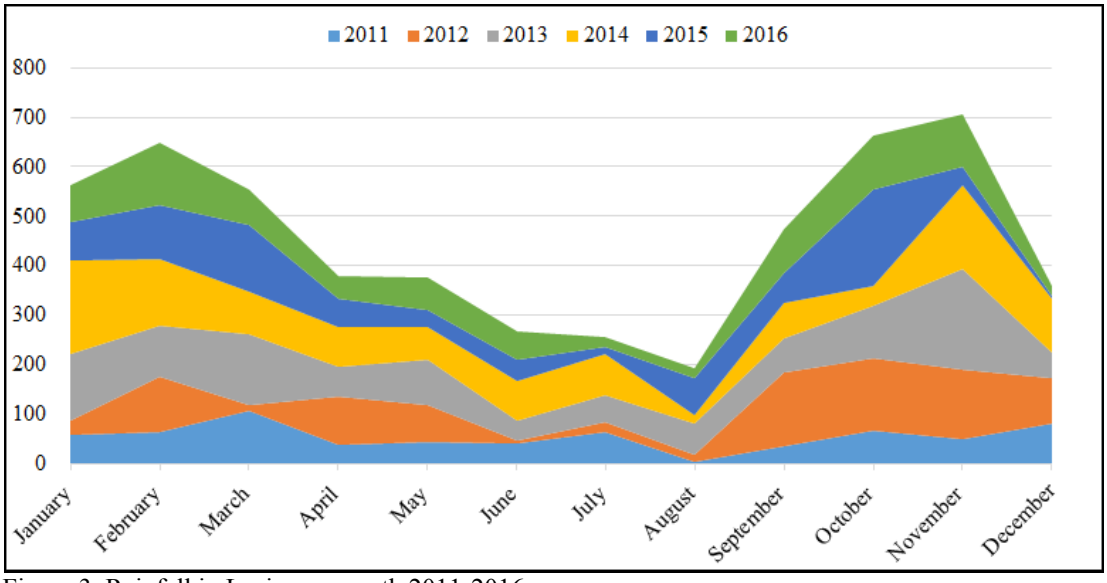


Figure 3. Rainfall in Lazio per month 2011-2016.
Source: Author's elaboration by Istat, 2012-2018.

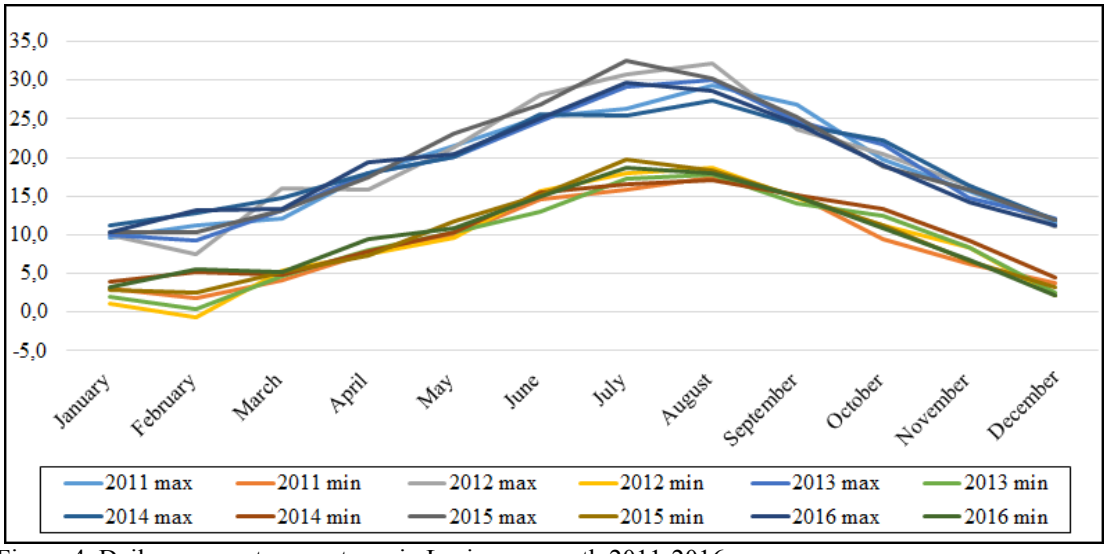


Figure 4. Daily average temperatures in Lazio per month 2011-2016.
Source: Author's elaboration by Istat, 2012-2018.

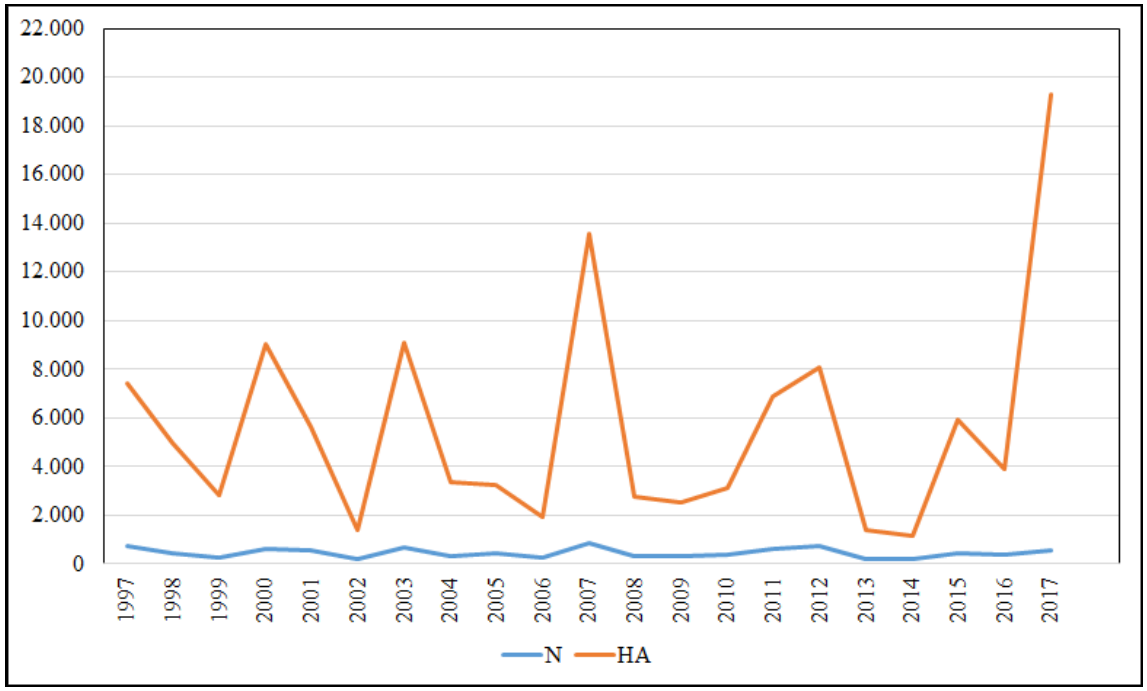


Figure 5. Forest fires in Lazio 1997-2017.
Source: Author's elaboration by Regione Lazio, 2011; Istat, 2012-2018; Tulumello et al., 2018; ARPC, 2018.

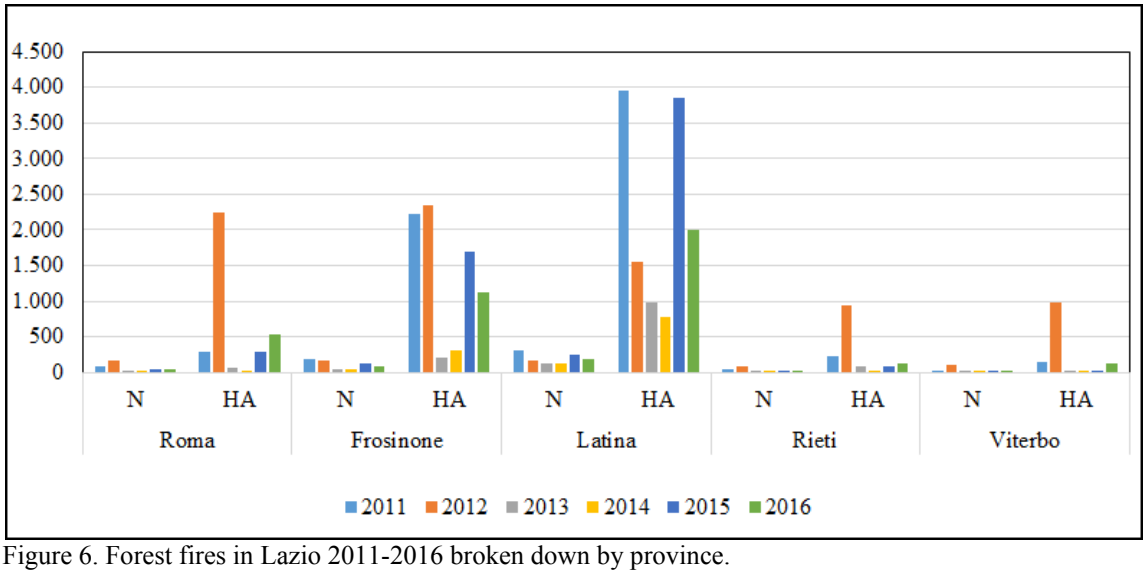


Figure 6. Forest fires in Lazio 2011-2016 broken down by province.
Source: Author's elaboration by Regione Lazio, 2011; Istat, 2012-2018; Tulumello et al., 2018; ARPC, 2018.

The trend that is highlighted, with deviations, is shown in its absoluteness organised in clusters of seven years: both with reference to the frequency of events and for what concerns the scorched area, the phenomenon in the region went from an acute phase at the turn of the century, to then undergo a slight decrease and overwhelmingly reappear in recent years, highlighting the inadequacy of the procedures and actions set up: in the seven year period from 1997-2003, 40,292 hectares were affected in 3,492 forest fires (an average of 5,756 hectares in 499 fires a year); in the following period, 2004-2010, 30,329 hectares in 2,818 fires (an average of 4,333 hectares in 403 infringements per year); in the seven year period 2011-2017, 46,674 hectares in 3,144 infringements (an average of 6,668 hectares in 449 blazes per year). It has been ascertained (Lovreglio et al., 2012) that in the seven year period 2004-2010 the arson attacks amounted to 79.4% and the unintentional fires amounted to 9.1%, suspicious to 10.2%, the natural fires (mainly lightning) and accidental to just 1.2%; in this seven year period the infringements were 86% wilful and 8.6% accidental, suspicious 4.7% and natural just 0.7%. A somewhat static situation in the wilful-culpable fires was to be found (for renewal of pastureland, recovery of agricultural land, gains from the disappearance of woods, saving in labour, poaching; pyromania; protest, resentment and insensitivity towards woodland), as a consequence of the reduction of the suspicious and natural ones, and the considerable increase of those classified as being accidental, often recorded as the work of unknown persons[4] (Tulumello et al., 2018).

The disaggregation of the categories was carried out in a range of motivations in relation to the social, economic, and productive profiles of the various territorial realities involved. The significant incidence of fire on farming and zootechnical activities is counterbalanced by the less relevant aspect of the fires deriving from cigarette butts and matches along roads and railways and those caused by tourists and campers inside woodland areas (Regione Lazio, 2011).

To the forest fires can be added the fires flaring up on the sites for the management and treatment of waste and in illegal landfills, often contested by residents as being too close to homes or not compliant. The twelve most serious cases were recorded between 2014 and 2017, filed as complaints against unknown persons: in 2014 (and in 2017), at the plant of Trattamento Meccanico Biologico-TMB "Ecologia Viterbo" in Viterbo, to the "Lazio Ambiente Spa" landfill at Colleferro (RM), at the composting plant "Kyklos" in Aprilia (LT); in 2015 (and in 2018), TMB Salario AMA plant in Rome; in 2016, at the plastic waste recovery plant "Ternipolimeri" in Cittaducale (RI), at the TMB "Pontina Ambiente" plant in Albano Laziale (RM, filed as unintentional), at the waste storage treatment plant "Cite" of Onano (VT); in 2017, at the illegal landfill (former mushroom farm) in the archaeological park of Centocelle in Roma, at the waste storage treatment plant "Eco X" in Pomezia (RM, filed as wilful-culpable), at the gasification plant of the Malagrotta complex of Roma, at the illegal landfill of Tor Cervara in Roma. Arpa Lazio, responsible for the monitoring in various stages (during the first hours of the fire to its extinguishing, in the hours prior to and following the event observing the values of the control unit, as soon as the fire had been put out and following days) of air, water and environment, in various cases detected the persistence of high levels of dioxin in the air surrounding the plants (Arpa Lazio, 2018).

The impressive dimensions reached in Lazio, took a toll of lives, caused serious harm to health, biodiversity, towns and villages, to infrastructures and public and private building stock in the zones affected.

In the face of the gravity of the situation, experience highlights the need for a deep reflection, *de iure condito* at the prevention and active fight level, and operational procedures by the state institutions, in particular those of the Corpo Nazionale dei Vigili del Fuoco (CNVF) (Fire brigade) and the Carabinieri Forestali (ex CFS), who work in synergy with the Civil Protection, which at regional level makes use of the ARPC and numerous resources[5].

[4] We cannot but express out concerns regarding the two provinces most hit by infringements, considered with lower density but demographically bigger in recent years (www.istat.it).

[5] These consist of: twelve Sale Operative Unificate Permanenti (SOUP), ten Coordinamenti delle Organizzazioni di Volontariato (OdV), 322 OdV

3. The current legislation

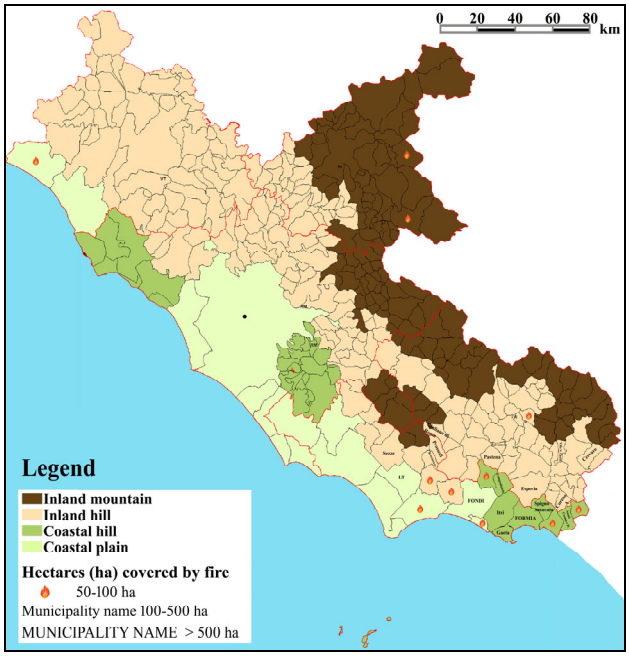
In order to foresee, prevent and actively fight against the phenomenon of forest fires, protecting the territories and forest and landscape heritage as a whole, specific legislation is in force, or more precisely, the Framework Law (lQ) on forest fires 353/2000[6]. This law is characterised by an approach aimed at prioritising the activities of forecast and prevention, rather than the emergency phase linked to the defence, control and extinguishing of burning fires. Prevention is indispensable as it comprises the defence activities aimed at acting on the causes of ignition and at containing the areas affected and the consequences of the fires (Blasi et al., 2004), supplying the territory with the necessary defence infrastructures and creating the conditions to increase the efficacy of the fire fighting. An essential point of the system outlined by the norm is represented by the "Regional plan for forecasting, prevention and active fire-fighting – Piano regionale di previsione, prevenzione e lotta attiva contro gli incendi boschivi" (AIB)", which the regions, directly responsible for territorial planning and management of all the available resources, must necessarily draw up. Until now Lazio has approved the one for 2011-2014 with DGR 415/2011[7], in which it is stated that the regional territory is to be considered "area at risk of forest fires and interface", referring to lr 39/2002, in which art. 65 sets down the period of maximum alert in Lazio as being from 15 June to 30 September.

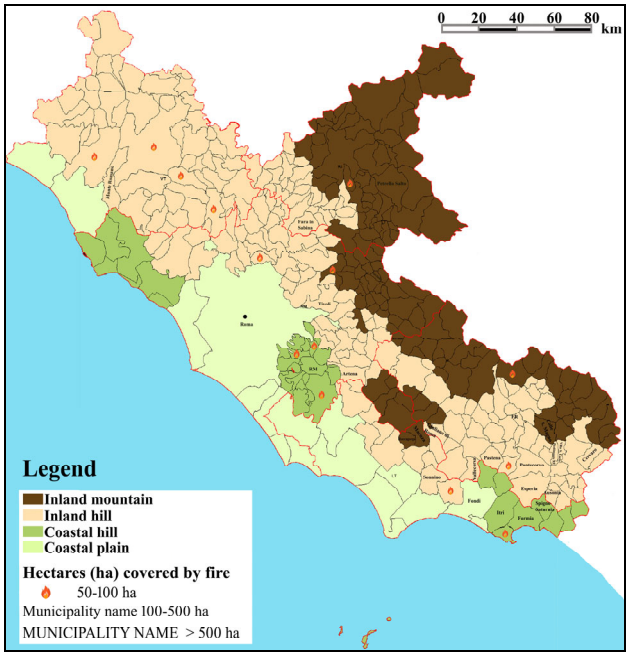
In the face of the forest fires that in recent years have represented a phenomenon of great concern, various legal instruments have been introduced: the dpCM 20/11/2001 with the "Guidelines for the drawing up of regional plans – Linee guida per la redazione dei Piani regionali" and Law 118/2002, containing the "Urgent provisions for the zootechnic sector and for the fight against forest fires – Disposizioni urgenti per il settore zootecnico e per la lotta agli incendi boschivi"; the dpCM 28/06/2002 and 06/06/2003 and the opCM 3295/2003, which for emergencies sets down the increase in the number of fire-fighting vehicles and the operational capacity of the existing air fleet; the dlgs 1/2018 "Codice di Protezione Civile", which entrusts the municipalities ex art. 12 with the implementation of risk prevention activities, the adoption of measures to prevent and eliminate serious dangers and for an emergency planning; dlgs 34/2018 "TU Foreste" and dm 12/01/2018 "Servizio antincendio boschivo del CNVF". In addition, l. 326/2003 (preceded by l. 662/1996), which prohibits the local councils from issuing building amnesties for regularisation for works resting on areas affected by fires, integrated by the Circular of the Ministry for Infrastructures 2699/2006 and by the Financial Law (lF) 2004, which includes the 10-year prohibition to build civil constructions, infrastructures and production facilities on forest areas affected by fires.

specialised AIB, 2,859 specialised volunteers AIB, 710 fire-fighting vehicles AIB, seven helicopters managed by the Centro Operativo Aereo Unificato (COAU) according to the Convenzione AIB 2018 stipulated between the CNVF and ARPC, following Framework Agreement (AQ) 16/04/2008 initialled between the Dipartimento dei Vigili del Fuoco and the CFS (ARPC, 2018). ARPC was set up with Regional Law (lr) 2/2014 and regulated with lr 25/2014. The CFS was militarised with dlgs 177/2016 and 228/2017.

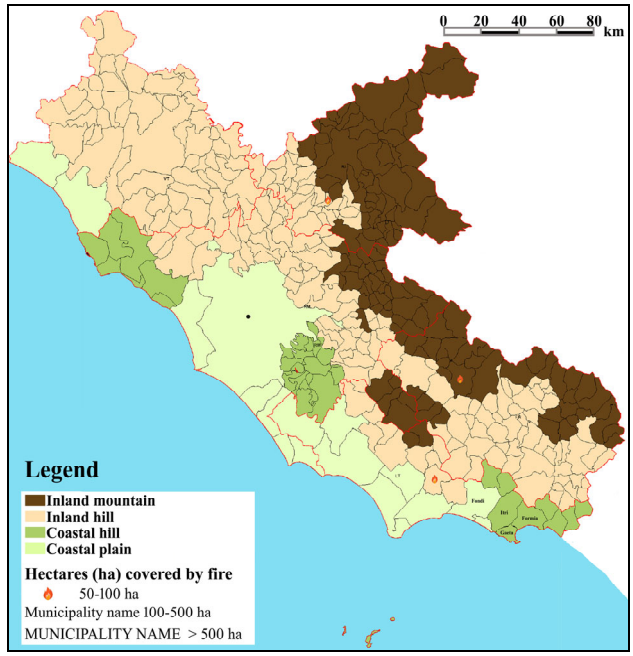
[6] It was updated with l. 100/2012 for "il riordino della protezione civile", preceded: by l. 3267/1923 (forestry) and 47/1975 "Norme integrative per la difesa dei boschi dagli incendi" (repealed); by the ddl 367/1993, 377/1994, 275/1995, 130/1997 and l. 275/2000 to prevent, tackle and repress forest fires.

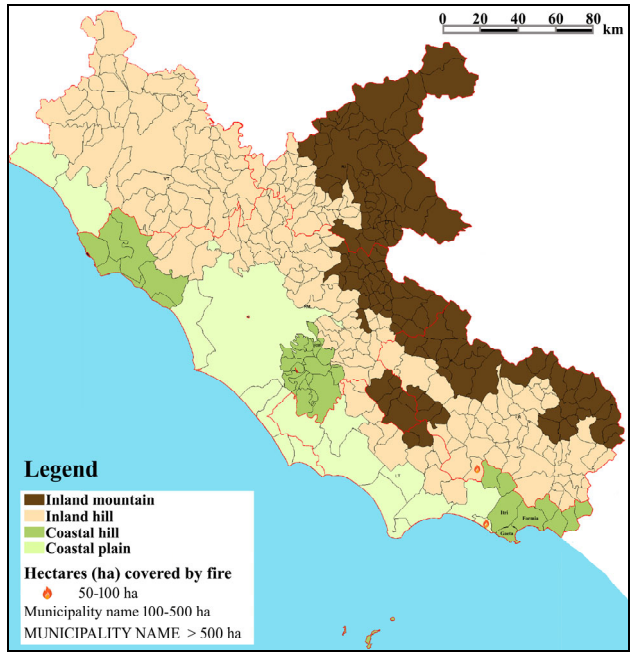
[7] While waiting for the new PAIB 2019-21 (presented), the present one has been updated and reviewed with the Regional Council Deliberation 344/2012, 286/2013, 553/2014, and resolutions G10209/2015, G07352/2016, G10021/2017, G07946/2018. The latter is the "Documento operativo per le attività antincendio boschivo (AIB) anno 2018", which sets down the guidelines for the carrying out of the annual AIB 2018 campaign and establishes that, on a daily basis, the Centro Funzionale Regionale must issue a summary bulletin for the forecast of susceptibility for the flaring up and propagation of forest fires on the regional territory, identifying for each province of Lazio three possible levels of susceptibility. It includes: pluviometric maps and GIS maps with risk indexes for the years 2006-2010, the cadastre of the water supply points in the case of fire and a geographical description of the region (Tulumello et al., 2018). It is recalled that climate, lithology and morphology make it possible to photograph the environmental complexity and the regional territorial mosaic (Blasi et al., 2008, 2010), indispensable elements for initiatives of governance.



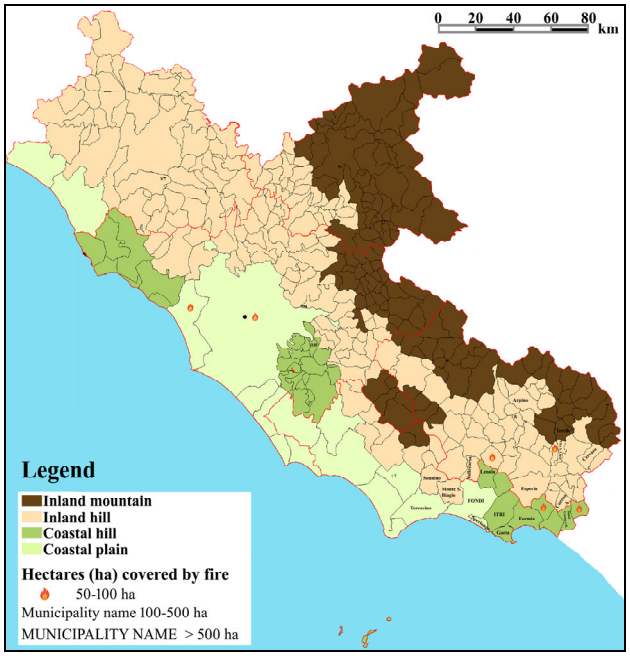


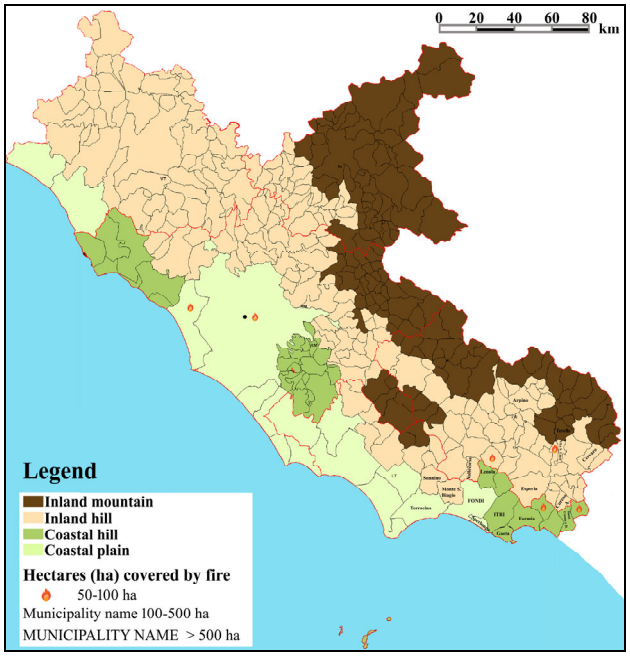
Figures 7 and 8. Forest fires in Lazio per province and municipality 2011 and 2012.
Source: Author's elaboration by Regione Lazio, 2011; Istat, 2012-2018; Tulumello et al., 2018; ARPC, 2018.





Figures 9 and 10. Forest fires in Lazio per province and municipality 2013 and 2014.
Source: Author's elaboration by Istat, 2012-2018; Tulumello et al., 2018; ARPC, 2018.





Figures 11 and 12. Forest fires in Lazio per province and municipality 2015 and 2016.
Source: Author's elaboration by Istat, 2012-2018; Tulumello et al., 2018; ARPC, 2018.

Last but not least, the ApCM 28/05/2004 and 11/06/2005, with the "Operational guidelines to tackle the risk of forest fires" – "Indirizzi operativi per fronteggiare il rischio di incendi boschivi" during the summer months; dpCM 27/07/2007 and opCM 3606/2007 with the – "Urgent provisions to tackle the state of emergency from forest fires in the regions of Lazio, Campania, Apulia, Calabria and Sicily" – "Disposizioni urgenti per fronteggiare lo stato di emergenza incendi delle regioni Lazio, Campania, Puglia, Calabria e Sicilia"[8], the five regions at the top of the national fire ranking (Istat, 2012-2018).

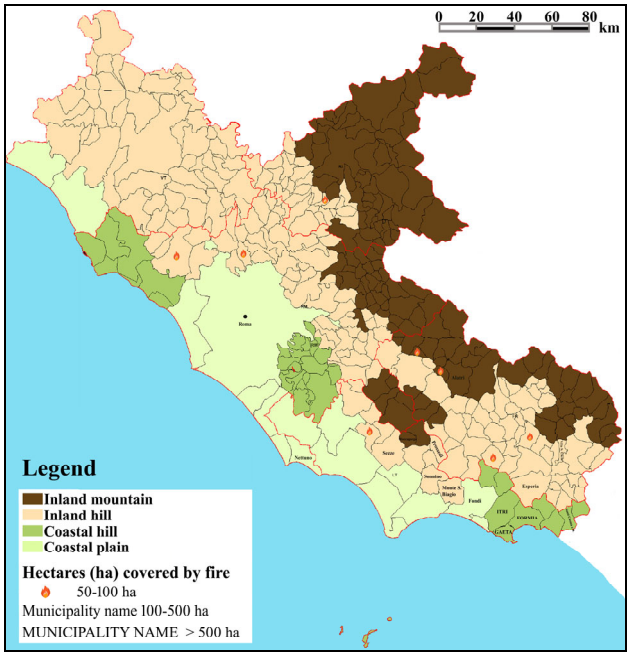


Figure 13. Forest fires in Lazio per province and municipality 2017.
Source: Author's elaboration by Istat, 2012-2018; Tulumello et al., 2018; ARPC, 2018.

The *corpus iuris* outlined above (incomplete) makes innovations insofar as for the first time it expresses the issue that is hidden behind a forest fire understood as 'fire prone to spreading over wooded, bushy or treelined areas, including any anthropized facilities and infrastructure within the aforementioned areas, or on cultivated or fallow land and pasture lands bordering on these areas' (art. 2 lQ 353/2000). Therefore, it can be the case of a fire that concerns the wood or the areas assimilated by it, or as a fire with an urban-rural interface (Lampin-Mailet et al., 2010) should it threaten to affect areas or strips

[8] At a later date: the opCM 3612/2007 and 3680/2008; the dpCM 23/10/2007 and 01/04/2008; l. 68/2015 on ecocrimes; delib. 33/2019 with the "Piano di protezione civile di Roma capitale".

of land in which the interconnection between anthropic buildings and natural areas is very close, geographical places where the urban and rural system meet and interact (Carroue et al., 2002). This type of fire can break out both in the proximity of the settlement (for example, due to the burning of plant debris or the lighting of fires during recreation in urban and/or peri-urban parks) or as the result of a forest fire[9].

The consequences for the natural balance are very serious and the time for the redevelopment of the ecosystem is extremely long (Vince et al., 2005). In fact, the burnt down woods often irreversibly lose the primary ecological functions of biodiversity, linked to the presence of species, ecosystems and habitats; the functions of climatic and hydrogeological stabilisation; timber production; the recreational and tourist function (Brugger, 2007; Pyne et al., 1996). One of the areas most at risk in Lazio is the Parco Regionale dei Monti Aurunci in the south pontine.

To the huge ecological damage must be added the serious risks to which people and private and public heritage are subject every year as a result of fires. In the same way must be added, among the indirect negative effects, the illegal constructions often built on land in the path of fire, in breach of the prohibitions and legal obligations. It appears from the CFS and ARPC data and from the criminal proceedings for arson (ex arts. 423, 424, 435, 449, 451, 635 c.p., which foresee a prison sentence from four to ten years for wilful arson and from one to five for culpable arson), that the nature of the fires in Lazio has for the most part been wilful or the outcome of negligence (Lovreglio et al., 2012). With regard to this, art. 10 of the lQ has obliged local councils to draft maps of the land crossed by fires and the identification of the areas most at risk: very appealing from the natural and landscape point of view, they are susceptible to particular interests from building speculators. To date, over 90% of the Lazio municipalities has an Emergency Plan and 355 have drawn up the "carta dello scenario di rischio incendio e incendio di interfaccia" (MIPAAFT, 2008; Tulumello et al., 2018). They referred to the Inventario Nazionale delle Foreste e dei Serbatoi Forestali di Carbonio a superficie forestale (INFC) of 2005[10], in which are listed the numerous different plant species and the delimitation of the interface bands, and the forest area is recorded: 605,859 hectares, equal to 1/3 of the whole regional territorial area 1,720,768 ha (17,207,68 kmq) (Table 1; Figure 14). Over 90% of the area is regulated and subject to hydrogeological protection, 30% of the wooded area (171,000 ha) is subject to environmental restrictions (protected natural areas and Natura 2000 network sites). All this has not been enough to reduce the fires.

4. The problems and initiatives of governance

A deep, radical and common review and remodelling of the organisational structure regarding fires will be able to guarantee the overcoming of the recourse to "emergency" type interventions in this delicate sector, to the advantage of prevention and counteraction strategies appropriate for the safeguarding of collective security and to the disadvantage of those who speculate, individuals and organised crime. The state apparatuses, having precise responsibilities in the matter, must collate their competences in order to define a common course of action with the region that makes it possible to homogenously rationalise resources and operational procedures over the whole territory. Thus, investing in the professional competences of everyone, synergies may be created indispensable to guarantee an effective fight against the phenomenon. They must comply with whatever is established at community level, in particular by the Resolution of 19/06/2015[11],

[9] According to the layers of vegetation it can be: subterranean, surface, foliage (Regione Lazio, 2011).

[10] Realised by the CFS, starting from the Carta Forestale del Regno of 1936 and the Inventario Forestale Nazionale Italiano (IFNI) of 1985. The INFC of 2015 is in the process of being drawn up by the Comando Unità Forestale Ambientale e Agroalimentare (CUTFAA), the CREA and Almaviva Spa (www.sian.it/inventarioforestale/).

[11] CEE regulations are also important: 3529/1986 (and modified 1614/1989) for the "Protezione delle foreste nella Comunità contro gli incendi"; 2158/1992 (and modified 805/2002), which collocates Lazio as a high risk area; 2152/2003, which led to the creation of a European information

which urges the Member States to prepare the PAIB quickly and to draw up the inventories with the annual study of the predisposing conditions for the spread of fires and the ones crucial in triggering them, since the pyrological potential changes year by year (Blasi et al., 2004); as well as implementing legislative frameworks for forest protection.

The European Parliament, at community level, requires the recognition of the details of the natural catastrophes of a Mediterranean type (drought and forest fires) and the consequent adaptation of the community instruments in the sectors of prevention, research, risk management, civil protection and solidarity 'so as to improve the response to this type of catastrophe at the level of each Member State'. It asks for awareness raising activities with regard to defendable space and fire insulation, above all having given new support with the Copernicus satellite, able to monitor forest fires, and the EU's civil protection mechanism for a coordinated intervention[12] according to the indications of the Green Paper (2010) "On forest protection and information in the EU: preparing forests for climate change".

The unlimited and uncontrolled allocation (a pioggia) of public funding to just anyone, as in the past for reforestation or restoration, maybe then to be put to use in ways hardly compatible with the peculiarities of the burned areas and with the mission for the conservation of nature, would not be of any help in getting out of the vicious circle. Rather, the mechanism of incentives for the procurers of building contracts to cash in on restoration funds very often risks being a deadly "social fuse" for the fires (WWF, 2008).

The recovery of areas burned by wildfires is difficult to foresee since it must be related to a very high number of factors such as: the frequency with which the area is affected by fires; the repetition of the phenomenon that damages its resilience; the extension of the area hit by fire; the distance of the area hit by fire from other areas with similar ecological features; the complexity of the ecosystem hit by the fire; the state of conservation of the biodiversity of the environment hit by the fire. Environmental recovery interventions are difficult as often the relationships between the living species are not known in detail nor are those between them and the ecosystem in which they live. The work of reforestation should be evaluated case by case, attempting as far as possible to foster the slow return of the conditions prior to the fire, since woods are complex living organisms which must be led back to the point at which the catastrophe interrupted their "growth". In such a sense, it is therefore necessary to try to adopt systems of forest management of semi-naturalness based on the principle of environmental sustainability and multifunctionality, also taking into account the threat of climate change[13].

	Viterbo	Rieti	Roma	Latina	Frosinone
Low woods	737	737	368	1,842	1,842
Sparse woods	343	737	2,809	368	1,423
Thickets	0	368	368	0	0
Shrublands	2,211	3,685	14,370	11,791	4,396
Inaccessible wooded areas	5,895	553	1,080	1,684	4,367
Total other wooded land	**9,186**	**6,080**	**18,995**	**15,685**	**12,028**
Spruce forests	0	0	0	0	368
Black pine forests, pinus laricio o loricate	368	1,474	1,474	368	4,790
Mediterranean pine forests	368	0	3,316	2,554	1,105
Other coniferous forests	368	0	737	0	368
Beech woods	368	35,372	11,791	737	23,443
Sessile Oak forests and others (roverella, farnia)	15,475	22,107	19,021	3,685	19,528
Bitter oak woods (farnetto, fragno, vallonea)	42,741	33,529	26,390	5,158	15,081
Chestnut forests	9,948	5,527	15,107	1,842	2,579
Ostrieti, hornbeams	3,685	33,161	18,423	7,001	33,899
Hygrophilous forests	1,842	3,316	1,474	737	1,842
Other deciduous forests	3,318	13,264	25,423	1,474	6,264
Holm oak forests	1,842	8,106	10,685	14,370	12,896
Cork oak forests	368	0	368	1,474	0
Other evergreen broadleaved forests	737	0	1,474	368	0
Total high forest	**81,428**	**155,856**	**135,683**	**39,768**	**122,163**
Artificial poplar groves	0	0	0	0	368
Others conifers	737	0	599	0	0
Total forest plantations for wood production	**737**	**0**	**599**	**0**	**368**
Other temporary unstocked land	**369**	**1,474**	**1,842**	**1,842**	**1,756**
TOTAL WOOD	**82,534**	**157,330**	**138,124**	**41,610**	**124,287**
OTHER WOODED LAND	**9,186**	**6,080**	**18,995**	**15,685**	**12,028**
TOTAL FOREST LAND	**91,720**	**163,410**	**157,119**	**57,295**	**136,315**

Table 1. Woods, other wooded areas, total forest area of Lazio per province (ha) in 2005.
Source: Author's elaboration by INFC 2005 (MIPAAFT, 2008; www.sian.it/inventarioforestale/).

system with data on forest fires *EFFIS* (*European Forest Fire Information System*).

[12] Ec.europa.eu.

[13] It must not be forgotten that fire is an element of land regeneration and foresees the return to renewed richness of flora within 2/3 years of the event if of a moderate nature and according to the intrinsic variability of the soil and vegetation resource in the previous phases. It is necessary to look at the proportions, nature and features of the fire and its development (Blasi and Biondi, 2017).

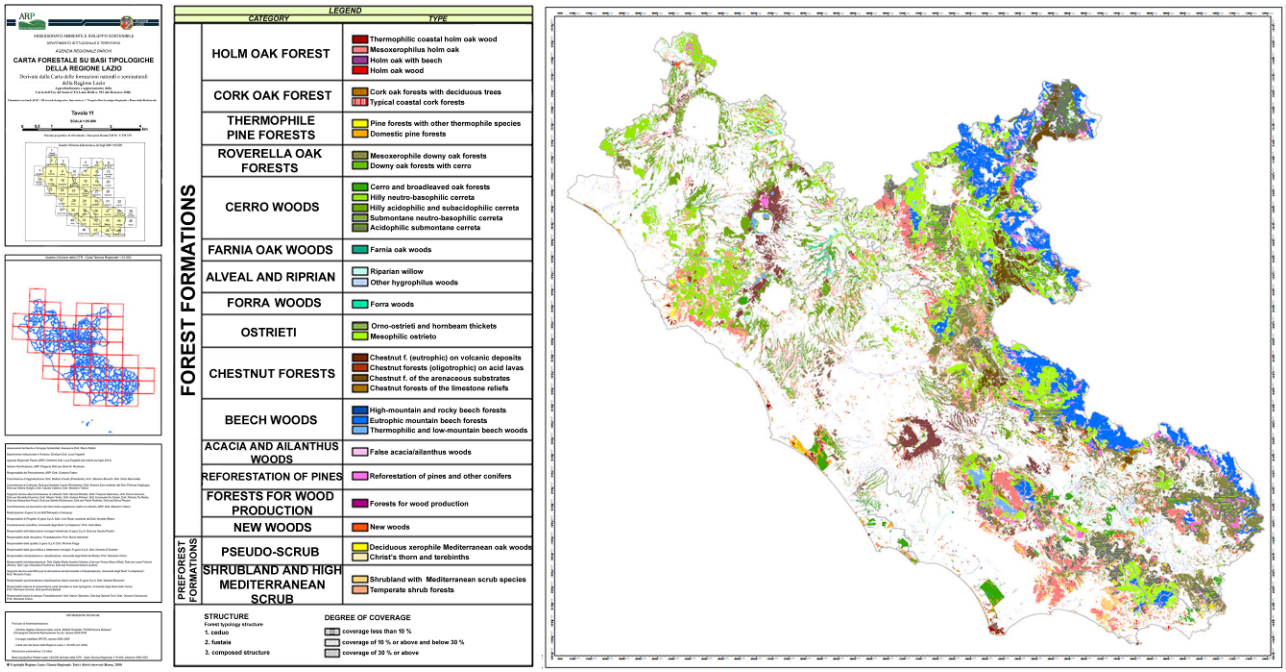


Figure 14. Forest map on typological bases of Lazio. Source: Author's elaboration by Chirici et al., 2014.

The choice of action must be shared with the stakeholders – experts and advisers, on whom the success of the forest and/or urban restoration depends. Without the direct involvement of local communities in this prevention and management process (Blasi et al., 2004), and without the prospect of an economic return, it is not possible to plan interventions over vast areas. In many landscapes, owing to their very typical differentiated mosaic structure, diversified approaches will be needed: agricultural areas alternated with devastated wooded zones connected by forest areas in different stages of biological complexity make up the common objective; landfills; urban-rural zones close to each other.

5. Education and good practice

Education and information on prevention, foreseen by art. 5 of lQ 353/2000, come into good practice. It is necessary to train technicians who know where and in what way to intervene[14], and it is important to offer the right education in schools, calibrating civil protection programmes according to different classes. Investments are needed in communication and information with the school world and the education centres of all types and level so as to increase the knowledge of risk often transmitted sporadically and randomly (Gallinelli, 2019)[15]. Syllabuses must be integrated for the purposes of growth and the promotion of an effective environmental culture, in activities of environmental and health protection. This can be done also through teaching cards and questionnaires. In fact, with regard to health it must be explained that the processes of combustion generate volatile and semi-volatile organic substances which are often toxic and which, as demonstrated by the scientific community (Steenland and Deddens, 2003) and by the regulations on air quality (dlg 155/2010 and smi), once dispersed into the atmosphere, then fall onto the zones bordering the wildfire area.

[14] Numerous projects have recently been financed at European level, among which: *Euforfire – European Forest Fire training council* and *"MEFISTO – Mediterranean Forest Fire Fighting Training Standardization* for education and training programmes.

[15] Support comes from PON 2014-20 under the responsibility of the Dipartimento della Protezione Civile assisted by the Ag. per la Coesione Territoriale and the CNR, to foster awareness and training.

With regard to fire-prevention planning, the importance is stressed of involving those living and working in the territory, with their active participation, in order to draw up solutions and implement strategies. Municipalities and forest owners (with incentives too) must be urged to strengthen their participation in consortiums, citizens to become the guardians of their forest area in the awareness of the wealth that it represents and the vulnerability caused by: the progressive abandoning of the land since the 1950s, the reduced pressure of forest uses and pasture, the consequent variation in invasive regimes with the expansion (uncontrolled) of woodland areas and shrublands or deciduous species instead of evergreens, and the rise in the construction of roads and houses. New cultivation interventions must thus be stimulated in forest environments (ex art. 4 lQ 353/2000), in the awareness that economic forestry aimed at improving the vegetation stability could limit the wildfires (Blasi et al., 2004); grazing for fire prevention purposes and a more conscious management of the resources (Pesaresi and Pavia, 2018).

It becomes fundamental to prevent the phenomenon in the high risk areas as if they were "sensitive targets", and therefore put in place more patrols, as well as specific direct and indirect actions: removal or burying of vegetation, thinning of the perimeter strips of the forests, creation of fire roads or protection walls; realisation of a good network of pathways and roads with clean slopes; putting up of notices on the correct burning procedure and descriptive signs both showing the danger of fires deriving from carelessness in areas frequented by tourists and indicating the presence of highly inflammable forest typologies.

It is also good practice to create synergies among the different realities at the various scales and to use open source data made available by the public administration: if the data (on landscapes, vegetation, density, ignition sources, climate, events, damage, behaviour etc.) are easily accessible, clear and high-quality, it becomes easy and immediate to create interactive maps with GIS applications, and thus foster the active participation of the population and the collaboration of associations, informed on both preventing fires and during the emergency stages (Cara, 2018). The GIS applications can reach a vast range of users, as they are dynamic and have a strong aesthetic-figurative impact. They make it possible to consider various parameters and study the territory in its diverse interrelated components (Kanga et al., 2014); in the case of fires they are useful to simulate the scenario of the damage and show the sequences with the original topographic conditions (Pesaresi and Lombardi, 2014; Pesaresi and Pavia, 2018); they offer the possibility for a critical reflection for the decision-making process aimed at interrupting the harmful long term dynamics and identify the steps to be taken by means of simulations and scenarios for a responsible and shared planning (Pesaresi et al., 2017; Sayad et al., 2019)[16]. Nevertheless, they must be used by specialised personnel, capable of triggering high-impact educational projects in schools (ESRI, 2006). Forest fires experts and decision makers have the responsibility to inform, communicate, and train. An effective communication program must answer the three following questions: Who is the target group? What message is to be passed? Which media should be used? Each answer is closely linked to the two other questions. Training allows to look further into scientific, technical, and practical details, or teaching techniques. The groups can be distinguished: children and teenagers, that can transmit the message to their parents; persons in charge for the regional planning (local counsellors, officials...); farmers or foresters working in or near the forest; all the people residing in forests and its edges; forest owners; tourists (FAO, 2001).

These initiatives are the prerequisites to successfully draw up winning strategies able to prevent and tackle even extreme events like megafires and to contain the damage to the landscapes and the economy, loss of biodiversity and life.

[16] The project *FRESh LIFE* (2015-2019) could be of interest to identify in four areas situated in Tuscany, Lazio and Molise, the integration of remote sensing in the sustainable management of forests, by means of the use of drones and LiDAR sensors and optics to map the forest variables and build an information support system.

6. Conclusions

Forest fires represent a highly critical element for the ecosystems of the Mediterranean forests. In recent years public awareness, the instruments of territorial planning and control of the territory have paid greater attention to the problem with the aim of a progressive reduction of the forest area destroyed by wildfires. Unfortunately, despite this, the phenomenon remains the same year after year and the emergency interventions do not always manage to effectively limit the damage.

In Lazio forest fires constitute a continuously evolving phenomenon. This dynamic does not only depend on elements external to man (phytoclimatology), but also on anthropic factors, such as legislation, fire-prevention organisation, management of the territory and the environmental awareness of the population. It is therefore of primary importance to use the patrimony of the statistical data available for the definition of future strategies to fight and control the phenomenon (Conedera and Pezzatti, 2005). Despite the important innovations introduced, the massive legal corpus and the number of initiatives have not yet led to a truly satisfactory degree of effectiveness of protection and interventions. The causes of the wildfires are always rather difficult to identify with any amount of certainty. If the cases of arson which can be ascertained are to be excluded, it is extremely difficult to identify the motivations leading up to the start of the fire. Even the mathematical models that have been developed and which are increasingly used in fire prevention practice do not always manage to give reliable answers regarding the forecast of an event; they can probably lead back to the complexity of the phenomenon, the evolution of which, as amply illustrated, requires more integrated and interdisciplinary risk management techniques.

The studies carried out so far have demonstrated how fires constitute a threat to the safety of the territory owing to the temporary reduction in the protective capacity of the forests in flames. They also constitute a threat to life and health. Detailed studies of the effects of fire and integration of knowledge into the fire prevention strategies can represent the fundamental premises for an improved wildfire management. The identification of a management strategy of the problem, so as to minimise the negative effects nevertheless remains an open question. It is not simple to educate, nor is it simple to prevent wilful intent or madness. Collaboration among all the actors is indispensable as well as the observation of the territory from a systemic viewpoint and the standardisation of practices and laws.

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