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Fight Environmental Crime

The Quantitative and Monetary Impacts of Forest Fire Crimes

WP3 Quantitative Analysis

Deliverable 3.2 b



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ABSTRACT

Wildfires have been recognized as one of the most significant environmental threats in Europe and particularly in the Mediterranean regions, giving rise to a multitude of environmental, social and economic impacts. However, forest fires are often not the result of a natural disaster or causes of fatality, but rather an anthropogenic phenomenon with direct dependence on social behavior, both voluntary and involuntary. Therefore the willful and malicious burning of forests represents a fire crime. This report focuses on the current status of wildfire impacts at the European and Italian regional levels, looking mainly at fire crimes in both quantitative and monetary terms and, to the same extent, at the relation between geographical distribution of such crimes and organized crime.

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LIST OF ABBREVIATIONS

| | |
|--------|---|
| WP | Wood Production |
| AAM | Analytical Assessment Model |
| AOT | Aerosol Optical Thickness |
| DGs | Directorates General |
| DG ENV | Directorates General for Environment |
| EFFIS | European Forest Fire Information System |
| EFCC | European Fire Causes Classifications |
| JRC | Joint Research Center |
| NIAB | Nucleo Investigation Anti Bosch |
| NWP | Non-wood Products |
| PCC | Protection from Climate Change |
| QAM | Quick Assessment Model |
| TEV | Total Economic Value |
| WP | Wood Production |

1 Introduction

Wildfires have been recognized as one of the most significant environmental threats in Europe and, particularly, in the Mediterranean regions (Requardt et al., 2007). According to the data gathered by the European Forest Fire Information System (EFFIS), the number of wildfires has moderately increased in recent years. The annual amount of burnt area fluctuates with no well-defined trend, although critical fire seasons in recent years have heavily impacted Mediterranean countries. Consequently, it is not surprising that during the last decade wildfires have gained more attention and increased concern about their environmental and economic effects and the loss of human lives. In Europe, the increasing awareness of the gravity of the problem was triggered by large-scale wildfires and their effects in southern European countries. Most of the total burnt area in Europe concentrates in this region where approximately 35,000 events occur per year (JRC, 2009). The huge number of forest fires and their systematic geographical location clearly show that they are not only an environmental issue, but have also significant social dimensions, affecting millions of people, by having major economic impacts and causing significant human casualties (Gonzalez Caban, 2007).

According to the National Wildfire Coordinating Group (2012), wildfires can be defined as uncontrolled fires caused naturally or by humans with susceptibility to expand into forested areas, arboreal or bushy, including any structures and infrastructures placed within such areas, or on cultivated or uncultivated land and pastures adjacent to these areas. However, forest fires are often not the result of a natural disaster or causes of fatality, but rather an anthropogenic phenomenon, with an exclusive, direct dependence on social behavior, both voluntary and involuntary (Leone and Lovreglio, 2003). Fire crime is defined as the willful and malicious burning of forests. It may be distinguished from other causes such as spontaneous fires and natural wildfires.

The European Union does not yet have a common forest fire policy for tackling fire crime, but it is involved in the development and monitoring of measures in the field of information, prevention and restoration of burned surfaces through various Directorates General (DGs)¹.

¹ DG Environment (forest fires prevention and monitoring, LIFE+ Regulation (EC) No 614/2007) and DG Agriculture and Rural Development (for supporting the restoration and fire prevention activities, Regulation (EC) No 1968/2005).

However, intentional and deliberate fire has recently been recognized as an environmental crime and has been included in the legal code of some Member States (i.e. Spain, Italy). For instance, in Italy, fire crimes are subject to prosecutions in a court of law. Particularly, in the Italian legal system, the criminal protection of the environment is almost entirely left to a series of misdemeanors, which fall outside the Penal Code. Among the few cases that do include the felony, there is art. 423-bis CC, which punishes anyone who causes a fire in forests or woods with four to ten years imprisonment. If the fire is caused by negligence, the punishment shall be imprisonment from one to five years. The penalties shall be increased if the fire endangers buildings or harms protected areas; the penalties shall be increased by half if the fire caused serious, widespread and persistent environmental damage. Also, it should be noted that Italy represents a quite important country study because of the strong presence of *organized crime systems*: the Legambiente Report (2014) argued that more than 51% of fire crime areas were concentrated in the four Italian regions where the presence of mafia clans is highest.

Policy and fire management measures at different levels are being developed and implemented to minimize the negative economic, social and environmental impacts of wildfires. The application of policy measures needs significant investments in terms of financial, human and organizational resources, which have to be justified and effective (Mavsar et al., 2011). The assessment of the use of financial resources in wildfire related measures (e.g. deterrence from fire crime) is crucial to justify and to select the most effective alternative in order to stem the different impacts of wildfires as much as possible (Mavsar et al., 2011). Lack of information on the environmental, social and economic damages arising from fire crime limits decision-making and investments for the prevention and the fight against wildfires (Nautiyal and Doan, 1974) and could lead to the misallocation of financial and organizational resources.

1.1 Some difficulties in evaluating forest crime impacts

The analysis of the impact of fire crimes in both quantitative and monetary terms presents several difficulties relating to both methodological and data availability issues. From the methodological point of view, the impact evaluation of fires has to take into consideration the fact that each fire produces several impacts (environmental, health, economic and social), which are very specific to the particular area where it occurs. Moreover, it is worth noting that fires directly impact benefits and resources that people receive from the environment, including for instance, provision of food, water and fiber, regulation of floods, drought, and land degradation (nutrient cycling). However, only a minor part of them exhibit a market price that can be used

as a possible proxy for assessing their value, while the majority of goods and services is not marketed. Statistics on fires quite often do not distinguish between natural and intentional causes of fires (fire crimes). As we have seen in deliverable D.3.1., to improve the availability of information and to support the fire prevention activity in the EU, the Joint Research Centre (JRC) and Directorate General for the Environment (DG ENV) of the European Commission have developed and implemented the European Forest Fire Information System (EFFIS). However, although EFFIS represents a useful and effective effort to collect data in a harmonized way among the Member States, it lacks adequate indicators to measure the economic, social and health impact of forest fire. To better cope with the lack of data and related indicators on the impact of fires, the JRC decided to develop two operational models for the evaluation of the social and economic impacts of fires (Mavsar et al., 2011). The first one (*Quick Assessment Model, QAM*) is used for small fire events (i.e., those mapped in the EFFIS database > 40 ha) and is designed to evaluate the fire damage cost using the reconstruction cost approach. The second model (*Analytical Assessment Model, AAM*) is conceived for the evaluation of the fire damage cost of large fire events (e.g., fire size > 500 ha) and is based on the economic analysis of the missed flow of forest goods and services. However, despite the general approach of both models to take advantage of the information available in the EFFIS database, they nonetheless seem to be quite limited in: (i) understanding other types of impacts (e.g. social and health); (ii) considering fire events below 40 ha of burnt area; and (iii) analyzing fire crime since no fire causes are taken into account. Therefore, given the broad heterogeneity of the fire events, the existing literature on the impact evaluation of fires typically focuses on a case-study approach. This seems to be the most effective strategy to gather detailed information regarding different levels of damage in order to develop regional fire management measures to minimize negative economic, social and environmental impacts of fires.

1.2 A brief survey of the literature

The literature dealing with the issue of fire events is, essentially, described by two phases: a pioneer one, during which there were very few studies regarding this topic, and a more recent phase where the wildfire criticalities were faced with detailed approaches and techniques. The pioneer phase publications discussed fire without thoroughly studying its different impacts on the ecosystems. For example, Ducamp (1932) and Laurent (1937) tried to explain the effects of wildfires on vegetation, considering their impact on erosion and forest degradation. While, during the more recent phase, most scientists, under the influence of non-neoclassical social

science ideas, were anxious to analytically demonstrate the different dimensions of wildfire impacts providing methodologies for the evaluation of forest fire risks and additionally policy implications. Therefore, it was only about 30 years ago that the subject was first objectively approached. Presently, several researchers have started to analyze the Mediterranean countries and the results give new perspectives on environmental, economic, social, and health impacts. Moreover, during the last decade, several meetings and conferences have also brought new knowledge on wildfire effects, considering also aspects such as post-fire vegetation, recovery costs, loss of infrastructure, safety issues for fire-fighters and for those who live and work in affected areas. As underlined, the existing literature on wildfire impacts mostly relies on case study methodology to assess short and long-term impacts and focuses on the nature and extent of impacts on wild-land in order to incorporate this information into wildfire policies, risk assessments, and management practices. Table 1 below summarizes some empirical contributions aiming at quantifying wildfire impacts:

Table 1: Empirical contributions on wildfires impacts

| <i>Author(s), Years</i> | <i>Research Question</i> | <i>Main Argument</i> |
|---------------------------|--|---|
| Morton et al., 2003 | Assessing the environmental, social and economic impacts of wildfire in U.S. | Total environmental, social, and economic impacts are a function of multiple factors, including fire size, location, and burn intensity. |
| Ortuno-Perez et al., 2004 | Assessing socio-economic deterioration that large forest fires have produced in the municipalities of the Tietar Valley (Spain). | Most affected socio-economic indicator was the number of holiday homes, which led authors to conclude that tourism is the most affected industry by forest fires. |
| Ciancio et al., 2007 | Methodological framework for the economic evaluation of specific impacts arising from wildfire. | Total economic damage is divided into three components: (i) <i>fire extinguishing costs</i> ; (ii) <i>environmental damage</i> ; and (iii) <i>external damage</i> . |
| Valese et al., 2011 | Quantify the economic impact arising from forest fires in North Eastern Italy (Veneto) in 2006, 2007, and 2008. | On average, every year in Veneto, the economic cost of wildfire is about 50 million Euros (i.e. every Veneto citizen pays about 10 Euros per capita due to forest fires). |
| Barnaba et al., 2011 | Estimating wildfires' health impacts by looking at their contribution to the European aerosol optical thickness (AOT). | Fire-related aerosols play a major role in shaping the AOT yearly cycle at the continental scale. |

To our knowledge, the only contribution in the literature that, following a holistic approach, tries to simultaneously quantify different dimensions of wildfire impacts is the *Wildfires*

Impacts Report edited by the Global Institute of Sustainable Forestry & Environmental Studies - Yale University (Morton et al., 2003). This report summarizes the current status of wildfire impacts in the United States by taking into consideration information from federal, state and local sources. Based on a survey of 10 large wildfires that occurred during the previous decade, the report provides examples on the magnitude of a variety of wildfire impacts by providing an opportunity to assess the utility for policy formulation and wildfire management. Economic impacts were, generally, obtained by considering fire suppression costs, damages to infrastructures and private properties; environmental impacts by taking into account the increased levels of carbon dioxide in the atmosphere, and damages caused to vegetation (burnt area), peat and soils, which results in loss of valuable habitat for autochthonous wildlife; while social impacts, including loss of income for the tourism industry, emotional stress associated with the fire events and damages to cultural or historic sites, are sometimes difficult to assess in detail. In the report, total environmental, social, and economic impacts are a function of multiple factors, including fire size, location, and burn intensity.

Using long term (2002–2007) satellite-based fires and aerosol data, coupled with atmospheric trajectory in Europe, Barnaba et al. (2011) estimates the wildfires environmental/health impacts by looking at the contribution of the European aerosol optical thickness (AOT)². Essentially, the authors found that fire related aerosols play a major role in shaping the AOT yearly cycle at the continental scale. In general, the regions most impacted by wildfire emissions and/or transports are the Eastern and Central European regions as well as Scandinavia. Conversely, a minor impact is found in Western Europe and in the Western Mediterranean regions. Moreover, they estimate that during springtime, 15% of the European fine fraction of AOT is attributable to wildfires. The estimated impact maximizes in April (20–35%) in Eastern and Central Europe as well as in Scandinavia and in the Central Mediterranean. An important contribution of wildfires is also found in summer over most of the continent, particularly in August over Eastern Europe (28%) and the Mediterranean regions, from Turkey (34%) to the western Mediterranean (25%). The results suggest that this fire related, continent-wide haze plays a non-negligible role on the European radiation budget and, possibly, on European air quality, thus, representing a clear target for policy intervention.

Generally, economic costs range from direct costs associated with fire fighting to loss of income from the land following wildfire incidents and damage to property. Restoring damaged habitats is also becoming an important component of post-wildfire recovery in sensitive

² Degree to which aerosols prevent the transmission of light by absorption or scattering of light.

environments, which is typically a very costly and time-consuming process. In this respect, monetization of specific impacts may be difficult to achieve, since not all impacts may be amenable to monetary analysis. The components of the damage resulting from wildfires have been subject to extensive analysis by various authors (Valese et al., 2011; Ciancio et al., 2007), both for the monitoring and reconstitution aspects and for environmental and social impacts. In this regard, Valese et al. (2011) measured the economic damage arising from forest fires in north-eastern Italy (Veneto region) looking at 10 selected large fires that occurred in 2006, 2007 and 2008.

Based on the information provided by the Italian Forestry Corp (Corpo Forestale dello Stato), for every single fire event it has been estimated that, in Veneto, on a yearly average, the economic cost of wildfire is about €50 million (equivalent to every Veneto citizen paying about €10 per capita). The applied methodology takes into account several indicators including: (i) costs related to the regular staff (manna employee of the Italian Forest Corp has a gross average salary of €1,700 per month) and extraordinary staff (volunteers are not paid, but the equipment they use has an average price of approximately €1,500), (ii) the cost of maintenance of helicopter and extinguishing means, (iii) costs incurred for the restoration of forests (€1,500-2000 per hectare), and (iv) damage caused by the decreased production of woodland products (€3,500 per hectare). Moreover, the Italian Academy of Forest Fire and the Italian Forest Corp (Ciancio et al., 2007) provided a methodological framework for the economic evaluation of specific impacts arising from wildfire. In particular, according to this study, the total impact is divided into three components: (i) *fire extinguishing costs* can be estimated by knowing the average personnel cost per hour, the number of people who were employed, the duration of the extinction operations and the cost of the equipment used. Usually, all of this information is collected for each fire event in Italy, (ii) *environmental damage*; a conventional approach for an analytical estimation of the environmental damage can refer to the cost of reconstruction or restoration, and (iii) *external damage* to physical assets (e.g. infrastructures, building, etc.) in terms of reconstruction costs; damage to human capital, or disability (temporary or permanent) and, in extreme cases, loss of human lives.

From a social point of view, according to Ortuno-Perez et al. (2004), the disappearance of forests as a source of wealth, due to fire events, involve the loss of many traditional jobs, such as conveyors, carpenters, tappers, loggers and charcoal burners. Particularly, the aim of their work was to determine the socio-economic deterioration that large forest fires have produced in the municipalities of the Tietar Valley (Spain) where large wildfires occurred in 2003. The study found a close relationship between natural resources and economic development,

especially in Pedro Bernardo and Guisando. This was shown by the fact that the number of holiday homes (the most important indicator for determining tourist activity) was lower in these towns than in other municipalities. They found that the most affected socio-economic indicator in the case of the Tietar Valley was the number of holiday homes, which led authors to conclude that tourism is the industry most affected by forest fires.

In conclusion, the traditional perspective in assessing wildfire impacts relies mostly on a case-study methodology. This approach seems to be the most effective strategy to obtain detailed information regarding different dimensions of such impacts in order to acquire the necessary knowledge to prevent and reduce negative economic, social and environmental impacts of wildfires. However, one point needs to be stressed: forest fires are often not the result of a natural disaster or causes of fatality, but rather an anthropogenic phenomenon, with an exclusive, direct dependence on social behavior, both voluntary or involuntary (Leone and Lovreglio, 2003). In this context, to our knowledge, no studies have been carried out so far in order to investigate the impacts of wildfires caused intentionally or not by humans (fire crimes).

1.3 Objective of the report

The main objective of this report is to analyze the extent of fire crimes and their impacts in both quantitative and monetary terms. To some extent, we also try to estimate whether the geographical impact of fire crimes is correlated to the presence of organized crime across Italian regions. Due to data limitations, our analysis will be conducted at two different geographical levels and take into consideration different time spans. Starting with a general overview of the forest fires issue at the European level in the last 20 years, the quantitative impact of fire crimes will be estimated both at the country-level for a selected number of European countries and at the regional-level for Italy. In particular, the European level analysis will be focused only on the environmental impact of fire crime while the regional level analysis on Italy will also take into account the assessment of other impacts arising from fire crime (health and material).

The monetary impact of fire crimes will be measured only at the Italian level. Such a methodological choice was due not only to the lack of suitable information at a wider geographical level, but also because, given the event-specific nature and the broad heterogeneity of this type of crime (i.e., protected areas, national parks, wooded/non-wooded area, etc.), the degree of accuracy in the estimate of the monetary damage is lower the larger the geographical area considered. The analysis was conducted using two different sources of data: i) the EFFIS database and (ii) the NIAB (Nucleo Investigativo Antincendi Boschivi) database. The European

Forest Fire Information System (EFFIS) database provides detailed yearly information on the number of forest fires, the size of the burnt area, the average fire size, and the different types of illegal activity (i.e. arsons and negligent fires). Data were collected for Mediterranean countries since 1985 and for the entire EFFIS network since 2005. The EFFIS network includes 24 EU Member States, 10 European non-EU countries and 4 MENA (Middle East and North Africa) countries. The EFFIS data are also available at country, region and province level (NUTS1, NUTS2, NUTS3). Information on the causes of wildfires is crucially important to understand whether a fire is or is not a crime, to support the environmental and civil protection policies and to design appropriate prevention measures.

The Nucleo Investigativo Antincendi Boschivi (NIAB) is the investigative body of the Italian Forest Corp responsible for the national coordination and investigation activities related to forest fires. The NIAB database provides detailed information on each forest fire event that occurred over the period 2000-2012. In particular, the most useful information for our analysis are: the size of the burnt area, the environmental characteristics of the burnt area (i.e., national parks, protected areas, etc.) the number of people who died or were injured from fire causes, the type of material damage (i.e., material assets, personal properties, etc.) the number of offenders detected, the number of offenders arrested, the duration and the number of people who were employed in the extinction operations and the cost of the equipment used.

2 Description of methodology

2.1 Methodology of the quantitative impacts of fire crimes

Forest fires can be defined as uncontrolled fire caused naturally or by humans with susceptibility to expand into forested areas, arboreal or bushy, including any structures and infrastructures placed within such areas, or on cultivated or uncultivated land and pastures adjacent to these areas (National Wildfire Coordinating Group, 2012). However, naturally occurring forest fires are far less frequent than man-made ones. The most frequent causes of natural wildfires are volcanoes, lightning, spontaneous combustion, and sparks caused by rockslides. Usually, forest fires “*are started by human negligence. Intentional arson, equipment sparks, discarded cigarettes, unattended campfires, controlled agricultural burns and power lines have all caused a number of wildfires in the past*” (Green Conduct Blog)³.

³ <http://greenconduct.com/blog/2013/07/25/the-environmental-consequences-of-forest-fires/> (accessed on 27th February, 2015).

With an increase in deforestation across the globe, highly flammable grasslands have taken their place. Statistically speaking, six times as many wildfires are started by humans than any natural causes (JRC, 2009). For this reason, knowing the causes of fires is crucial to a) understanding the extent of the fire crime, and b) supporting the environmental and civil protection policies by designing appropriate prevention measures.

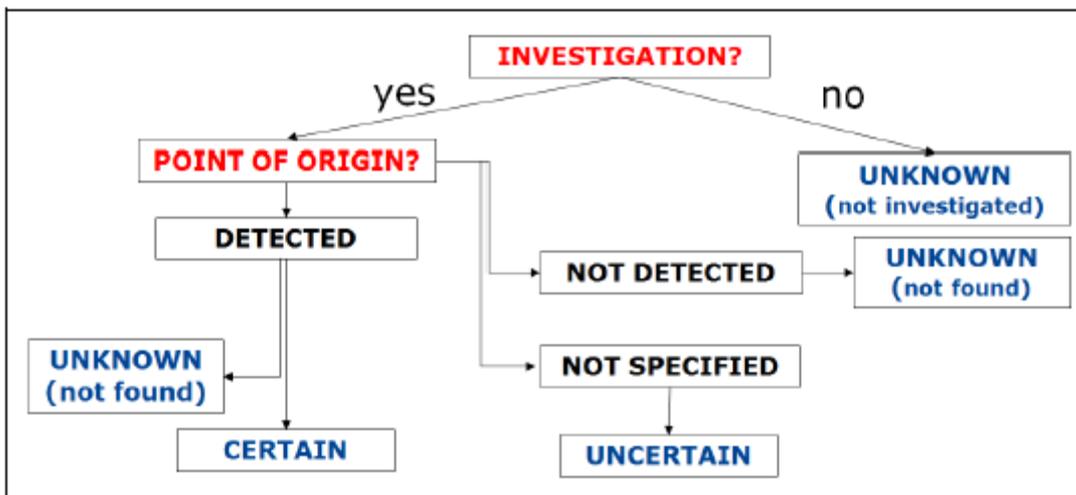
At the European level a joint scheme with four causes (deliberate, accident/negligence, natural and unknown) of fires has been implemented to collect detailed information since 1992. European countries use national schemes that are often much more comprehensive than the simple four common causes, but they are not coherent with other country schemes and comparisons may be arduous (San Miguel and Camia, 2010). The need for a new EU scheme, more accurate than the four simple categories and harmonized across European countries, has been developed in order to improve the level of information and knowledge on the origins of forest fires in Europe. This new scheme has been designed to be pertinent with few changes to the previous country settings, preserving as much as possible the historical data series of each country while also utilizing as much as possible the level of detail of the information available. A key feature of the new scheme is that common fire causes categories have to be widely agreed/recognized; in addition, clear and unambiguous definitions are an integral part of the new classification scheme. The new classification of fires, similar to the former “Common Core” EU scheme, considers the following categories:

- Unknown*: wildfire with no cause found;
- Natural*: any wildfire caused by natural origin, with no human involvement in any way;
- Accident*: wildfire unintentionally and indirectly caused by human without use of fire, connected neither to will nor to negligence, rather to fatality;
- Negligence*: Wildfire unintentionally caused by human using fire or glowing object, not connected to fatality;
- Deliberate*: Wildfire intentionally caused by human with the use of fire;
- Rekindle*: Wildfire caused by re-ignition of a previous fire, due to latent heat or embers.

As emphasized by San Miguel and Camia (2010) in their executive report on European Fire Causes Classifications (EFCC), the new scheme is based on the objective evaluation of the fire cause through accurate investigations that aim to identify the point of origin of the fire (ignition point). If the point of ignition is known (and possibly also the ignition device), the fire cause might be recognized and reported in the database as certain (however, in some cases, even with known point of ignition, the cause cannot be identified and remains unknown). If not, the fire

cause is to be reported as either uncertain or unknown. If the point of ignition cannot be precisely specified, remaining vaguely identified while different elements from the investigation support specific assumptions about the fire cause, then the fire cause can be reported as uncertain. If the point of ignition is not detected, the fire cause is included in the database as unknown. Figure 1 below shows a binary key to assessing the level of certainty in the identification of the fire causes in order to be recorded in the fire database.

Figure 1. Determination of the level of certainty of fire causes identification



Source: San Miguel and Camia, 2010.

Box 1. Kernel density maps and the Delphi method

Kernel maps allow for an immediate cartographic visualization of both two- and three-dimensional images of the ignition points of the events in the geographic area taken into account; thanks to this, it is possible to plan prevention activities. Such activities are crafted on the areas where specific types of wildfire frequently occur and sometimes with impressive regularity: they are almost always unintentionally caused and the consequence of supposed agriculture-related or cleaning-up needs.

The Delphi method is a technique to obtain solutions to an issue. It relies on a panel of anonymous experts, who propose independent solutions, refining them in two or three rounds. At the end of each round, a facilitator drafts a summary of the different answers proposed by the experts and their supporting arguments and sends the summary back to all the experts, so that they can reconsider their own answers on the basis of their colleagues'. Finally, a sort of arithmetic mean of the answers is determined.

The person who coordinates this process is called a *facilitator*: as a matter of fact s/he arranges the answers of the group of experts. The experts are chosen on the basis of their expertise and are asked to contribute opinions and points of view.

The Delphi method is therefore a systematic and interactive review method based on independent reasoning of selected international experts; it values experts' opinions, experiences and intuitions and allows using these unique resources as valuable information when complete and exhaustive scientific knowledge is not available.

The extent of environmental, social, and economic impacts of fire crimes is therefore, a function of several factors such as the size, intensity, location and causes (deliberate and negligent) of the event. In order to investigate the wide range of impacts arising from fire crimes, based on the availability of data and consistently with the objectives of the present report, some environmental, material and health indicators are taken into account.

From an environmental point of view, the occurrence of a forest fire can change the physical and structural characteristics of the vegetated landscape, thus producing significant variations of its vegetation, soil and fauna. Ecosystems affected by fires lose, totally or partially, the plant cover for a period of time lasting up to several months or even years. During this time, the soil is exposed to erosion by wind and water that can contribute to the degradation of the nutrient cycling (carbon, nitrogen, phosphorus) essential for vegetation, and thus, for herbivorous animal species. The environmental impact of forest fires on ecosystems is a result of the combined effects of warming produced during the fire combustion (fire severity), and the loss of vegetation (fire size). Therefore, the most critical fires are those reaching very high temperatures at surface level giving rise to the loss of nitrogen and organic materials from the soil. In order to estimate the environmental impact of forest fire crime, at least three main fire

components should be considered, namely fire cause, fire size, and fire severity (fires whose burnt area > 50 ha). While fire cause allows us to select only fire crimes, fire size helps to quantify the burnt area that could have been potentially damaged. Moreover, knowing fire severity is useful to assess the average damage level. Hence, we estimate the environmental impact using the following indicator:

$$\text{Environmental Impact (ha)} = \text{Average Burnt Area per fire (ha)} * \text{Number of fire crimes (1)}$$

With regard to our regional level analysis within Italy, to give a more accurate estimate of the environmental impact, we combine the indicator (1) with the land use type (for example, forest vs. non-forest) and for forest characteristics (i.e. protected areas, national parks and so on). In particular, the NIAB database provided us detailed information on each forest fire event that occurred over the time period 2010-2012. Therefore, we are able to exactly quantify the magnitude of the environmental impact that occurred in protected areas, with regard to the ordinary statute regions served by the Italian Forest Corp, by summing the burnt area (in ha) due to forest fire crime that occurred at the provincial level.

Moreover, wildfire provides an ample field to put human life in danger. Research on the human health impacts of forest fires takes place in a variety of disciplines including forestry, epidemiology, anthropology and so on. Particularly, epidemiologic studies (see Barnaba et al. 2011) focus on health consequences of air pollution created by the burning of biomass, while there are only few example of research (Viegas et al., 2009) aimed at investigating accidents involving fire fighters and the population affected by forest fires. The loss of human lives is the worst outcome arising from forest fires and this has repeatedly occurred in the last years. However, other important issues concerning human health are related to injury and pathologies affecting fire fighters and people with respiratory problems. Due to data limitations, we estimate the health impact of fire crime using the following as an indicator of the number of dead and injured people as a result of fire crime in Italy during the decade (2003-2012).

$$\text{Health Impact} = \text{Number of deaths and Number of injured (2)}$$

Finally, another important wildfire impact to focus on is the material impact. Namely, the loss of income due to the destruction of human physical assets that takes place in forest fires affected/surrounding areas. Occasionally, forest fires burn houses, factories, farms and

infrastructures, in a zone commonly called the *wildland-urban interface*⁴. In recent years, as living standards have evolved, rural areas have been populated by secondary homes, which have enlarged the wildland urban interface. Therefore, human populations and related physical assets are exposed at a higher risk of forest fires than ever. As stated in a CRS Report (2012), it seems that one or more fires annually have burned down several to a few hundred homes and outbuildings (sheds, garages, etc.) in Europe, and these structures generally have ignited in one of two ways: through direct contact with fire or through radiation (heating from exposure to flames). Given data availability, in order to quantify the material impact of fire crimes in Italy over the decade 2003-2012 we look at four main categories of assets: (i) *vehicles* including wagons, bicycles, motor vehicles (motorcycles, cars, trucks, buses), railed vehicles (trains, trams); (ii) *material assets* (any item of movable personal property, such as furniture, domestic animals, etc.); (iii) *real estate* (i.e. immovable property, buildings or housing in general but also farmland); and (iv) *farm animals* (e.g. cows, horses, pigs, chickens, ducks, rabbits, goats, sheep).

Material Impact = Vehicles, Material assets, Real estate and Farm animal (3)

2.2 Methodology of the monetary impacts of fire crimes

Generally, economic costs range from direct costs associated with fire fighting to loss of income from the land following wildfire incidents and damage to property. Restoring damaged habitats is also becoming an important component of post-wildfire recovery in sensitive environments, which is typically a very costly and time-consuming process. In this respect, monetization of specific impacts may be difficult to achieve since not all impacts may be subjected to monetary analysis.

The components of the damage resulting from wildfires have been the subject of extensive analysis by various authors (see, for example, Barbosa et al., 2004 and Bovio et al., 2005), both for the monitoring and reconstitution aspects and for environmental and social impacts. From this perspective, the Italian Academy of Forest Fire and the Italian Forest Corp (2007) provided

⁴ The wildland-urban interface is an area where structures (homes, factories, farms) are in or near wildlands (forests or rangelands). For more information, see CRS Report RS21880, Wildfire Protection in the Wildland-Urban Interface, by Ross W. Gorte and Kelsi Bracmort (2009).

a methodological framework for the economic monetization of specific impacts arising from wildfire. In particular, according to this study, the total impact is divided into three components:

- *Fire extinguishing costs*: these costs can be estimated by knowing the average personnel cost per hour, the number of people employed, the duration of the extinction operations and the cost of the equipment used. Usually, all this information is collected for each fire event (e.g. Italy);

- *Environmental damage*: a conventional approach for an analytical estimation of the environmental damage can refer to the cost of reconstruction or restoration. The estimation criterion is based on the assumption that an asset is worth (at least) what it costs;

- *External damage* to physical assets (e.g. infrastructures, building, etc.) in terms of reconstruction costs: damage to human capital, or disability (temporary or permanent) and, in extreme cases, loss of human lives.

$$\text{Total Damage} = \text{extinguishing costs} + \text{environmental damages} + \text{external damages} \quad (4)$$

It is worth noting that, considering the existing methodology applied in literature (Ciancio et al., 2007) and the good availability of data, we can proceed in providing new insights for the assessment of different impacts arising from fire crimes and for the economic monetization of some of them. To this end, we rely on some in depth case studies (Maracallo and Favale di Monfasso-Italy) that could offer a springboard to advance theoretical arguments with much broader policy implications.

3 The quantitative impact of forest crime

Whether caused by human negligence or naturally occurring, wildfires can generate significant impacts on the economy, on the environment, on the affected communities and on human health. An appropriate analysis on different impacts of wildfires could be crucial in terms of an effective, appropriate prevention to mitigate the loss of biodiversity and an efficient protection action can slow the ecological degradation and contribute to the development of an effective environmental policy at the European Level.

3.1 General overview of the phenomenon at the European level

Forest fires represent a persisting problem for most Mediterranean countries showing a rather upward trend during the last twenty years, even though these countries have been

investing more funds in methods to prevent and mainly suppress them (Tampakis at al., 2005). Therefore, fire trends in Europe show a high concentration of fire events and, more importantly, fire impacts in the Mediterranean regions. Most of the total burnt area in Europe concentrates in this geographical area. The average area affected by fires annually across Europe reaches 500,000 ha, and 95% occur in the Mediterranean countries, with approximately 35,000 events per year. Assuming that such a phenomenon is regularly distributed over time, then this averages about 100 fires a day throughout the year (European Commission, JRC technical Report, 2012).

The long time series of wildfire events available from the EFFIS database for these five southern countries (Portugal, Spain, France, Italy, and Greece) validates a separate analysis, as mentioned earlier. The latest data reported by the EFFIS system on the EU are those for the year 2012, which have been elaborated and published in 2013. Table 2 below summarizes the extent of wildfires that occurred in Mediterranean countries during the last two decades, taking into account the number of fires, the burnt area and the fire severity. At this stage of the analysis, we disregard fire causes, which will be the object of a more detailed analysis in the following sections.

Table 2. Number of fires, burnt area and fire severity in the five southern Member States (1992-2012)

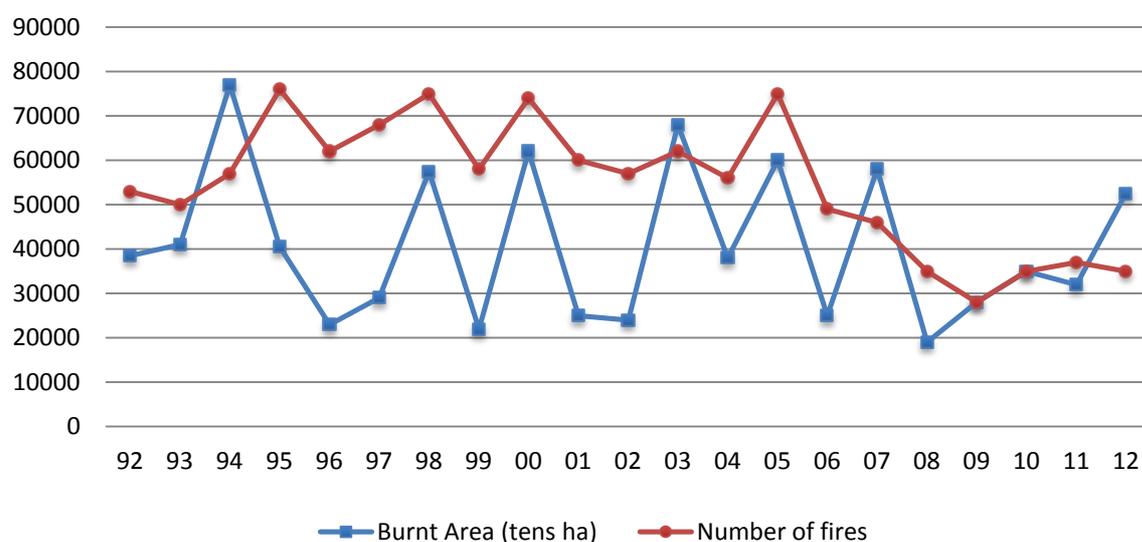
| | ITALY | SPAIN | PORTUGAL | FRANCE | GREECE | TOTAL |
|-------------------------|---------|---------|----------|---------|--------|-----------|
| Number of Fires | | | | | | |
| 2012 | 8,252 | 15,902 | 21,176 | 4,105 | 1,559 | 38,994 |
| % Total in 2012 | 16% | 31% | 42% | 8% | 3% | 100% |
| Average 1992-2002 | 11,078 | 18,152 | 22,250 | 5,538 | 1,748 | 58,851 |
| Average 2002-2012 | 9,736 | 18,337 | 24,949 | 4,406 | 1,695 | 50,645 |
| Total 1992-2012 | 203,294 | 335,793 | 409,485 | 103,357 | 34,188 | 1,086,117 |
| Burnt areas (ha) | | | | | | |
| 2012 | 130,814 | 209,855 | 110,231 | 8,600 | 59,924 | 519,424 |
| % total in 2012 | 25% | 40% | 21% | 2% | 12% | 100% |
| Average 1992-2002 | 147,150 | 161,319 | 102,203 | 22,342 | 44,108 | 448,938 |
| Average 2002-2012 | 83,878 | 125,239 | 150,101 | 9,433 | 49,238 | 430,798 |

| | | | | | | |
|----------------------|-----------|-----------|-----------|---------|----------|------------|
| Total 1992-2012 | 2,442,234 | 3,775,048 | 2,383,346 | 580,421 | 1037,106 | 1,0132,344 |
| Fire Severity | | | | | | |
| Fires 2012 | 8,252 | 15,902 | 21,176 | 4,105 | 1,559 | 38,994 |
| Burnt area > 50 ha | 68% | 69% | 62% | 58% | 60% | 64% |
| Average 1992-2002 | 11,078 | 18,152 | 22,250 | 5,538 | 1,748 | 58,851 |
| Burnt area > 50 ha | 52% | 51% | 47% | 34% | 38% | 48% |
| Average 2002-2012 | 9,736 | 18,337 | 24,949 | 4,406 | 1,695 | 56,645 |
| Burnt area > 50 ha | 55% | 52% | 51% | 48% | 46% | 52% |

Source: authors' elaborations on EFFIS Database

In 2012, in these five most affected countries, forest fires burned a total area of 519,424 ha: such an impact has been well above the average value of the last 20 years (about 400,000 ha) and among the highest since 2000. On the other hand, the number of fire events has been below the average and among the lowest over the last two decades (see Table 2). Figure 2 clearly shows this unusual trend by combining the number of fires per year with the total burnt area in the five southern Member States from 1992 to 2012. In particular, 2012 displays a local maximum for burned area despite the decrease in the number of fires that occurred, which is well below the average for the period. This evidence shows that wildfires during this period were clearly much more destructive than in past years; notably, in 2012, 64% of the total area affected by fires was burned by high-intensity wildfires making vegetation communities highly vulnerable. Therefore, as already emphasized by Montealegre et al. (2014), fire severity plays a key role in determining the magnitude of wildfire impacts on the environment in terms of total tree mortality, loss of biodiversity (i.e., in the form of animal species, vegetation) giving rise to a deep ecological landscape change.

Figure 2. Burnt area and number of fires in the southern EU Member States (1992-2012)



Source: authors' elaborations on EFFIS Database

3.1.1 Some estimates on fire crimes in Europe

As we already emphasized previously, forest fires are often not a natural disaster or fatal to human life, but rather an anthropogenic phenomenon. Hence, knowing fire causes is crucial to understanding the extent of such an environmental crime and to support the environmental and civil protection authorities in designing appropriate prevention policies.

By definition, an environmental impact is a change that directly affects an ecosystem through damages caused to the vegetation, peat and soils, which result in loss of valuable habitat for autochthonous wildlife. Therefore, a possible way to quantify the environmental impact is to focus on the countries' areas affected by forest fires and assess how much of this area has been burnt because of fire crimes. To this end, we need to determine *a priori*, for each Member State, how much area has been burnt on average, by a single forest fire during the last decade. Then, by combining such information with the forest fire causes, the environmental impact at European level for the decade 2003-2012 is estimated by the following indicator:

$$\text{Environmental Impact} = \text{Average Burnt Area per fire (ha)} * \text{Number of fire crimes}$$

Using the EFFIS database, which provides information on fire causes (natural, accidental,

responsible and deliberate), table 3 shows the number of fire crimes, the related burnt area (environmental impact) and the percentage rate of fire crime for the 21 Member States over the decade 2003-2012.

Table 3: Assessing the environmental impact in the 21 Member States from 2003 to 2012.

| Country | Number of fire crimes | Average burnt Area (ha) | Environmental Impact (ha) | Crime % |
|----------------|-----------------------|-------------------------|---------------------------|---------|
| Belgium | 270 | 0.19 | 52.7 | 8.3 |
| Switzerland | 154 | 1.28 | 197.3 | 47.3 |
| Czech Republic | 559 | 0.29 | 163.7 | 21.3 |
| Cyprus | 280 | 5.02 | 1,198 | 19.8 |
| Germany | 450 | 0.54 | 244 | 15.9 |
| Spain | 89,282 | 9.5 | 848,241.4 | 63.7 |
| Finland | 229 | 0.06 | 14 | 2.0 |
| France | 6,033 | 4.06 | 24,494.4 | 28.5 |
| Greece | 3,819 | 4.09 | 15,619.71 | 45.6 |
| Croatia | 3,160 | 0.54 | 1,724.4 | 20.2 |
| Hungary | 206 | 1.98 | 408.2 | 11.5 |
| Italy | 48,105 | 11.613 | 558,643.4 | 65.6 |
| Lithuania | 397 | 0.27 | 108.7 | 12.4 |
| Latvia | 784 | 0.22 | 170.5 | 15.9 |
| Poland | 1,288 | 4.5 | 5,9035 | 57.2 |
| Portugal | 17,870 | 3.8 | 72,838.3 | 31.6 |
| Romania | 478 | 1.69 | 807.9 | 30.4 |
| Serbia | 822 | 2.11 | 1,734.4 | 33.1 |
| Slovenia | 135 | 1.61 | 218.4 | 22.7 |
| Slovakia | 294 | 0.33 | 98.5 | 12.5 |
| Turkey | 1,413 | 1.90 | 2,691 | 20.4 |
| TOTAL | | | 1,535,572.41 | |

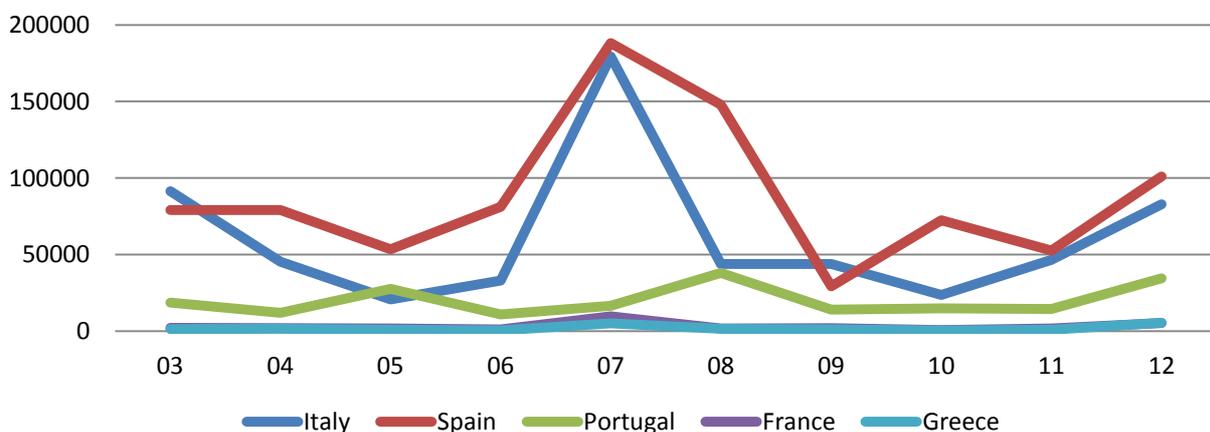
Source: authors' elaborations on EFFIS database

During the last decade, in the 21 Member States, forest fires due to human causes burned a total area of 1,535,572.41 ha. Environmental impact varies notably from one country to another according to the meteorological conditions related to the geographical location of the countries. The extent of the environmental impact due to fire crime is particularly significant for the southern Member States. Looking at table 3, we see that Spain was the most affected country in terms of burnt area due to fire crimes, with 40% of the whole burnt area in Europe (848,241.4 ha), followed by Italy (558,643.4 ha) and Portugal (72,838.3 ha). Conversely, less affected countries were Finland (14 ha), Belgium (52.7 ha) and Slovakia (98.5 ha). Another important aspect to consider is the extent of fire crime. In this framework, taking into account only known forest fire causes, we are able to assess the magnitude of such crime by considering the

percentage ratio between fire crime causes (deliberate and negligent) and the total number of wildfires. Forest fire events due to deliberate actions and negligent behaviors account for 66% of the total number of forest fires in Italy, followed by Spain (64%) and Poland (57%) (see Annex 1 for more detailed information). Despite a quite low environmental impact of fire crime in Poland (5,903.5 ha), the fire crime rate is fairly significant. This is mainly due to the cultivation techniques involving the burning of stubble of the large lands (50% of the country land is cultivated). Therefore, among forest fire causes in Poland, the consequences of fire transfer from the meadows and plant residuals subjected to burning has been growing in recent years, this is also due to the insufficient national legislation for tackling fire crimes (Ubysz, 2003).

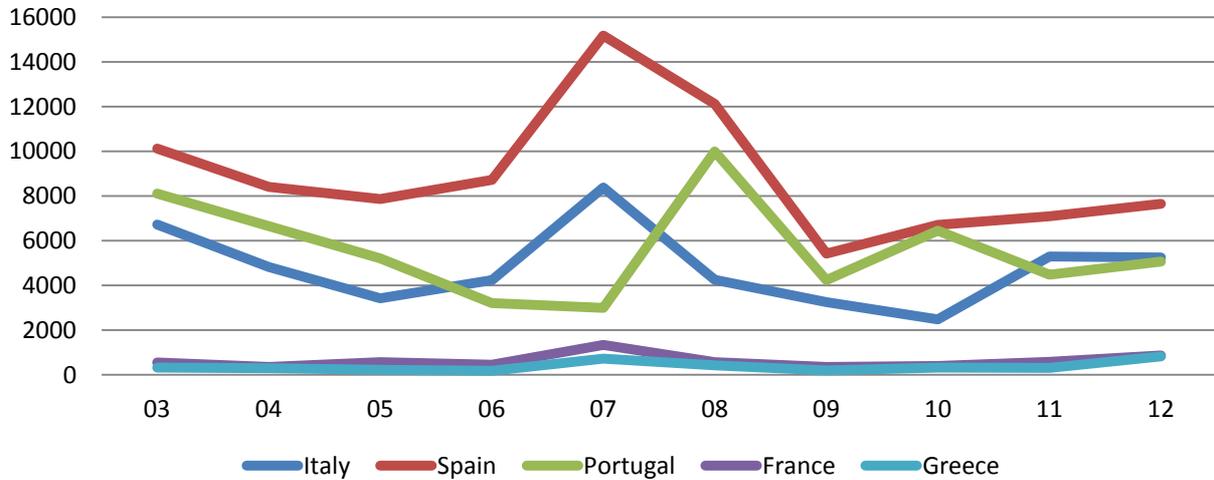
As already emphasized in the previous section, the long time series of fire crime available from the EFFIS database for some southern countries (Portugal, Spain, France, Italy, and Greece) should deserve an *ad hoc* extensive analysis to investigate the trend over time of the environmental impact caused by fire crime. Figures 3 and 4 show the evolution of the number of fire crimes and related total burnt area per year in the five southern Member States over the last decade (2003-2012). The statistics vary considerably from one year to the next but they mostly follow the same trend for the different countries, which clearly denote that the total burnt area could depend mostly on seasonal meteorological conditions. For instance, during the “dramatic” summer of 2007, Europe experienced extremely hot and dry weather conditions that led to a number of extraordinarily large forest fires over the Iberian Peninsula and the Mediterranean coast. Overall, taking into account the five countries all together, we can see that 2012 exhibits a local maximum for burned area; the 2006, 2007 and 2008 fire seasons were the worst years followed by three consecutive relatively “positive” years.

Figure 3. Trend of the environmental impact (ha) in the five most affected European countries (2003-2012)



Source: authors' elaborations on EFFIS database

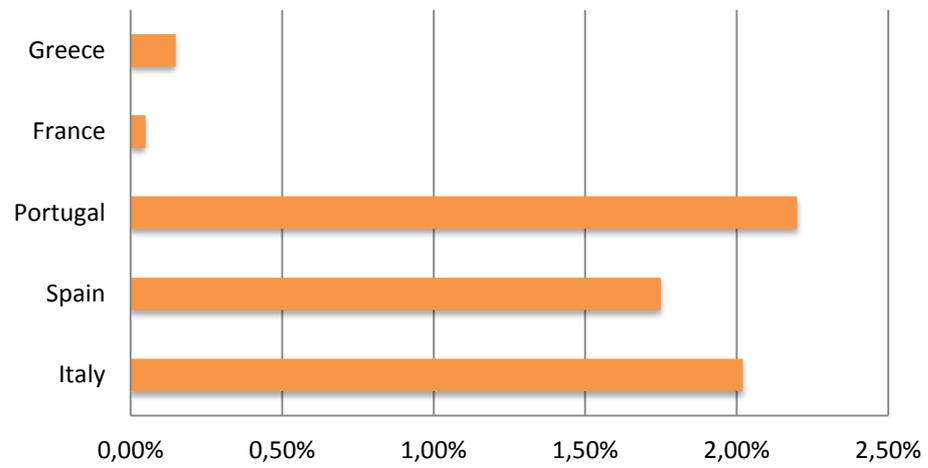
Figure 4. Number of fire crimes in the five most affected European countries (2003-2012)



Source: authors' elaboration from European Fire Database

Since the area of each country is different, and the area at risk within each country is also different, the comparisons of the magnitude of the environmental impact among countries cannot be absolute. Therefore, it could be convenient to consider the burnt area for each country and, thus, the environmental impact with regard to the individual country's surface area. Figure 5 shows how much of each country's total surface has been burnt due to fire crime during the last decade. Overall, Portugal has been the most affected country considering the ratio (2.02%) between burnt area (201,210.9 ha) and total surface area (9,209,000 ha), followed by Italy (2.02%), Spain (1.75%) and, to a lesser extent, by Greece (0.15%) and France (0.05%).

Figure 5. The environmental impact by country total surface



| | Italy | Spain | Portugal | France | Greece |
|----------------------------|-------|-------|----------|--------|--------|
| ■ Burnt Area/Total Surface | 2,02% | 1,75% | 2,20% | 0,05% | 0,15% |

Source: authors' elaboration from European Fire Database

3.2 Forest fire crime in Italy

3.2.1 Normative framework

In Italy, the legislation regarding activities to contrast forest fires was derived from the following constitutional principles:

–Italian Constitution - Article 9. “The Republic [...] safeguards the landscape and the historical and artistic heritage of the Nation”;

–Italian Constitution - Article 32. “The Republic safeguards health as a fundamental right of the individual and as a collective interest [...]”;

–Law 121/1981, Article 16, paragraph 3 assigns to the State executive bodies the capacity of public protection for the safeguard of public safety and the maintenance of public order in those areas where forest fires occur;

–Law 225/1992 and subsequent amendments and additions (Law 353/2000), establishes the National Service of Civil Protection to which functions of civil protection: prediction, prevention and proactive fight (monitoring; surveillance; sighting, alarm, and fire extinguishing through vehicles both by land and air; management, coordination and suppression of forest fires) are assigned;

–VI Title, Penal Code - crimes against public safety and special law - Law 353/2000, on public security to safeguard public safety and activities to contrast forest fire crimes.

The legislation regarding activities to contrast forest fire crimes has been enriched over time with the following norms:

- Decree August 4th, 2000 "Amendments to the Penal Code" converted into Law 275/2000;
- Establishment of the Investigative Unit Against Forest Fires (Nucleo Investigativo Antincendi Boschivi, N.I.A.B.) within the former General Directorate of Forest, Mountain, and Water Resources, on August 10th, 2000 now reorganized and strengthened by Decree of the Head of the Forest Body in February 2013;
- Law 353/2000 "Framework law concerning forest fires"; Law 353/2000 contains very important elements to address the issue, including:
 - The legal definition of "forest fire"
 - The assignment of crucial tasks to the regions for fire prevention and fighting.
 - The provision of a census of all the burned areas;
 - The introduction, in Title VI of the Penal Code, of a specific crime for forest fire (Article

423-bis, Penal Code);

- The temporary prohibition of new constructions on the areas touched by the fire;

Under Article 2, Law 353/2000 "The term *forest fire* indicates a fire susceptible to expand on wooded, bushy, or arboreal areas, including any anthropic facilities and infrastructure located within the aforementioned areas, or on cultivated, uncultivated, and grazing lands neighboring such areas."

For the purposes of the application of the penal norm, it is fundamental to properly define the concept of "forest" as the object to safeguard.

At the national level, Article 2 Legislative Decree no. 227/2001, amended by Article 26 Law 35/2012, contains useful references for the legal definition of *forest*:

- It specifies that the terms *wood* and *forest* are equivalent, that is, in legal terms they have exactly the same meaning;
- It does not provide an unambiguous definition of *forest*, which could be applied as it is throughout the national territory; in fact, Regions are entrusted with the exact identification of the concept;
- It equates to forest under any circumstance and therefore throughout the country: a) the lands encumbered by the obligation of reforestation for the purposes of defense of the territory and protection of the landscape and of the environment in general; b) forest areas which, for various reasons, are temporarily lacking trees and shrubs; c) the glades and all other limited areas that interrupt the continuity of the forest;
- It introduces the so-called "state" definition of forest, which is valid until the enactment of regional laws and, unless otherwise already defined by the Regions themselves, the territories referred to in paragraph 6 are considered to be a "forest";

Constitutionally, Article 117, as amended by the Constitutional Law 3/2001 is important, as it assigns;

- Exclusive competence to the State in the field of environmental safeguard policies (paragraph 2); and
- Concurrent competence to State and Regions regarding the promotion of environmental and cultural assets (paragraph 3):

Consequently, the definition of *forest*, which is functional to the safeguard of the landscape, the environment, and the ecosystems, is in the sole responsibility of the state that manages it according to the mentioned national legislation. In certain cases, it may be the Regions' duty to establish a different concept of *forest* for the territories under their jurisdiction and only for different purposes connected to regional powers, such as the development of agriculture and

forests, the management of wood production, the reforestation activities, and the management of the chestnut trees. Regional powers are therefore limited to productive and managerial aspects of the forest. Consequently, in the case of criminal proceedings that have the forest as their object, the forest must be identified as the common good. In particular, when curbing forest offenses or crimes committed within the forests, law enforcement agents and the judiciary authority have to identify the *forest* as the common good to be protected according to the unvarying criteria established at the national level, which are precisely those indicated in Article 2, paragraph 6. As a matter of fact, the common good that is protected by the criminal law, can only be the same throughout the national territory and the application of the criminal law cannot allow differences in the ways the common good is regarded across regions. Therefore:

–Only a few regions have legislated in compliance with the provisions of Article 2, paragraph 2 of the 2001 Legislative Decree n. 227.

–Regional laws establish a concept of *forest* that goes essentially back to the State's definition, with the introduction of some specific features that must adapt the definition of *forest* to the forest areas under their jurisdiction and in accordance with regional policies for the management of such areas.

–In defining the *forest*, some Regions report typological and cultivation-related dimensions, which in some cases coincide with the State's definition, but in other cases are even more restrictive. Moreover, in some Regions the size parameters of the forest are defined by regulation, not by law. In other Regions, instead, the definition of forest is contained in legislative measures that regulate different matters.

Finally, several regions, in addition to defining the concept of *forest*, have also established what is not considered a forest. In principle, in such regions, the following are not considered to be forests: city parks, gardens and picnic areas, cultivations of Christmas trees of less than 30 years of average age, the rows of plants and the avenues of trees, the botanical gardens, the orchards, the woody crops when on lands that are not objected to hydro-geological constraints, the abandoned lands, the truffle-cultivated areas of artificial origin, the meadows, and the wooded pastures.

3.2.2 Characteristics of forest fire crime

The forest fire crime under the Article 423-bis of the penal code, is an offense of presumed danger, which means that the threat to the common good is sufficient reason for an allegation: the existence of an actual offence is not necessary. The danger is already in the action, in the potentially dangerous behavior. The Article stipulates that:

- The regulation is intended to protect public safety and national forests and forestry;
- The forest fire crime occurs when there is a fire that is susceptible to expanding to wooded areas;
- The attempted forest fire (performing suitable and unequivocal actions that cause damage to the common good and/or are presumed dangerous - threatening to the forest, even when the action is not fulfilled or the event does not occur) occurs when the fire ignition caused by the criminal has not occurred yet.

The characterizing features of the new article of the Penal Code regarding forest fires can be summarized as follows:

1. A specific common good is subject to legal protection: the woods or forests;
2. The sentence is increased in case of deliberate cause;
3. The sentence is increased also for the typical cases of crime against the environment;
4. The rule contributes to defining the legal concept of forest fire.

3.2.3 Prohibitions and requirements on the matter of forest fires

The law prohibits:

- Reforestation activities and environmental engineering supported by public funds for 5 years after a fire;
- The construction of infrastructures and buildings aimed at civilian settlements or productive activities or pastoral and hunting activities in the 10 years following a fire;
- The zone change of the land in the 15 years following a fire. This restriction must be reported, under penalty of nullity, in any contract, stipulated within 15 years from the fire, of sale of land and properties that fall within those areas.

For the purposes of the effective application of such a system of constraints and requirements, the Framework Law requires that every year the municipalities survey the areas affected by fires through a dedicated land registry. This provision has been disregarded by the majority of the municipalities, which resulted in government measures in 2007, intended to promote compliance to the regulations by the defaulting administrations. In any case, this type of prohibition appears to have worked as an effective preventive measure on the actions of destruction of the forest through fire for the purpose of property speculation, since the criminal project is in any case going to be nullified on account of the constraints mentioned above.

In case of violation of the prohibitions and non-compliance with the requirements, in addition to criminal sanctions, fixed or proportional administrative sanctions will be applied as well.

3.2.4 Administrative sanctions

Article 10 of the Framework Law also prescribes the following administrative sanctions:

- The violation of the prohibition of grazing on stands of wooded areas touched by fire is punished with a administrative penalty, from 30 to 60 euros per head (of cattle);
- The administrative penalty to be applied in case of violation of the hunting ban oscillates between 206 and 413 euros.
- The violation of the prohibition of construction of buildings and/or facilities and infrastructures aimed at civilian settlements and/or production activities on stands affected by fire is punished by the penalty provided for in Article 20, paragraph 1, letter. C) Law 47/1985 (imprisonment up to two years and a monetary fine that varies from a minimum of 15,493 to a maximum of 51,645 euros);
- Finally, a civil fine ranging from 1,032 to 10,329 euros is applied to those who violate the prohibitions established in the annual plans issued by the regions. Such plans identify, in the areas and periods at risk of forest fire, all the prohibited actions that may, even potentially, determine the onset of a fire.

Such penalties are doubled in the case that the offender belongs to CNVVF - National Corp of Firemen, the CFS - Italian Forest Corp, the Armed Forces, other police forces of the State, the Regional Forestry Service, the Regional Civil Protection Service, a volunteer organization committed in the fight against forest fire.

3.2.5 Administrative penalties and responsibilities for environmental damage

The following provisions are also relevant:

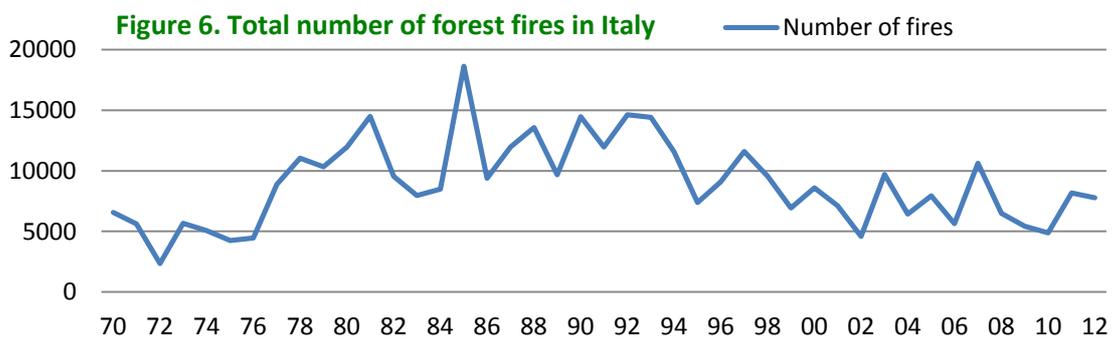
- The **General Prescriptions and Forestry Police (PMPF)**, contained in the Forestry Law – Royal Decree no. 3267/1923, which enacts the prohibitions and requirements, whose violation entails the application of administrative penalties;
- The **Consolidated Laws of Public Safety (T.U.L.P.S.)** - RD no. 773/1931, Chapter V "Provisions on the prevention of accidents and disasters" whose Article 59 defines the violations subjected to monetary administrative fine;

Art. 18 Law 349/1986 - Establishment of the Ministry of Environment and rules regarding environmental damage, on the right to compensation for environmental damage, the

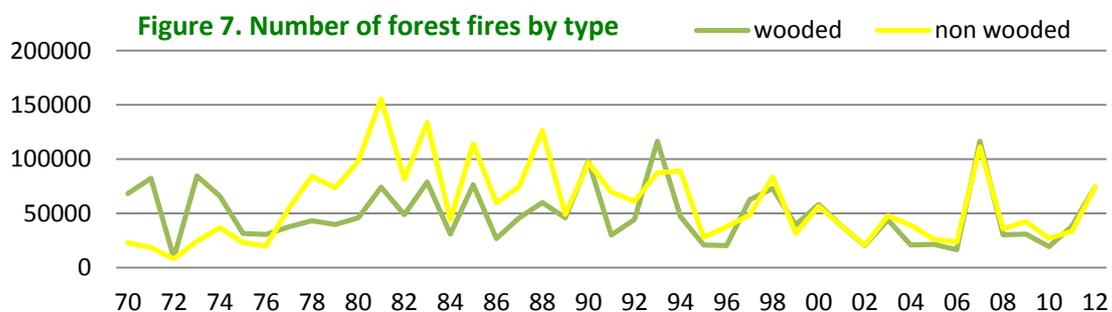
determination of which includes the costs incurred for the active fight and the estimated damages to the topsoil and the soil.

3.3 An evaluation of the impact of forest fire in Italy

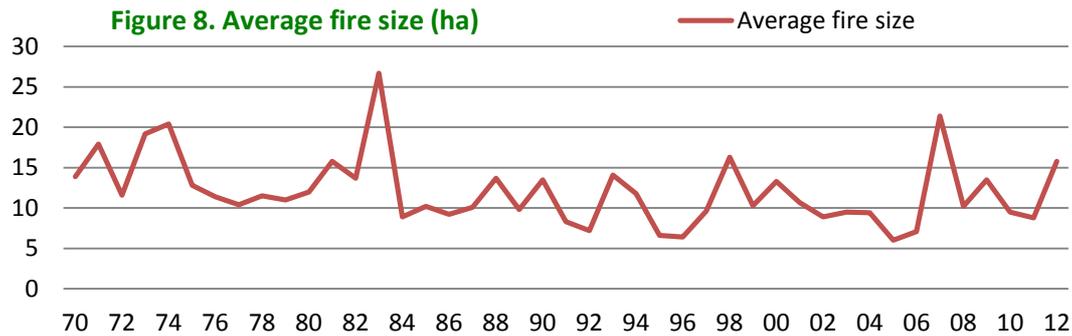
Among the Mediterranean countries, Italy represents one of the countries most affected by wildfires. Fire events cover the entire Italian peninsula, however, the larger wildfire events normally occur in the south. In 2012, throughout the country there were 8,252 forest fires, which burnt 130,814 ha in total, of which 74,543 were wooded. Compared to the previous year 2011, the total number of forest fires increased by just 1%, while the total areas burnt by fire increased by over 80% (in particular the wooded areas, which increased by 94% compared with an increase in non-wooded areas of 67%). The complete archive of the data relating to forest fires collected by the Italian Forest Corp is available from 1970 to the present. Figures 6, 7 and 8 show in detail the historic trend of forest fires in Italy (1970-2012) in terms of number of forest fires, burnt area (wooded and non-wooded) and average fire size.



Source: authors' elaboration from Italian Forest Corps data



Source: authors' elaboration from Italian Forest Corps data



Source: authors' elaboration from Italian Forest Corps data

The number of wildfire events rose in the 1970s, subsequently stayed less than 10,000 per year until 1978, when there were more than 11,000 fire events, and persisted constantly high during the 1980s and 1990s. From 2000 to 2007, the average number of events decreased by one-third in comparison with the previous 20 years. The affected wooded area has been significant from the early '70s and has continued to be above 50,000 ha on average for over the last 30 years, decreasing to about 40,000 in the last 8 years. The non-wooded burnt areas were moderately low during the 1970s, with an average of 36,000 ha per year, reaching the highest value in the period 1980-89 with more than 93,000 ha per year and then dropping in the 1990s, with an average value of about 65,000 ha, further decreased to 45,000 in the last years. The average burnt area per fire has reduced gradually over the decades, from 13.5 to 12.7 ha during the 1970-1980s, to 10.6 in the 1990s, with a slight increase in the years 2000-2007 to 10.8 ha. The year 2012 shows a local maximum for burnt area (51,9424 ha), but at the same time the number of fires occurred decreased to well below the average recorded in the last two decades. As often emphasized by the Italian Forest Corp, the most critical seasons were recorded in 1985, for number of fires (18,664), in 2007 for forest area affected by fire (116,602 ha) and in 1981 for total area (229,850 ha).

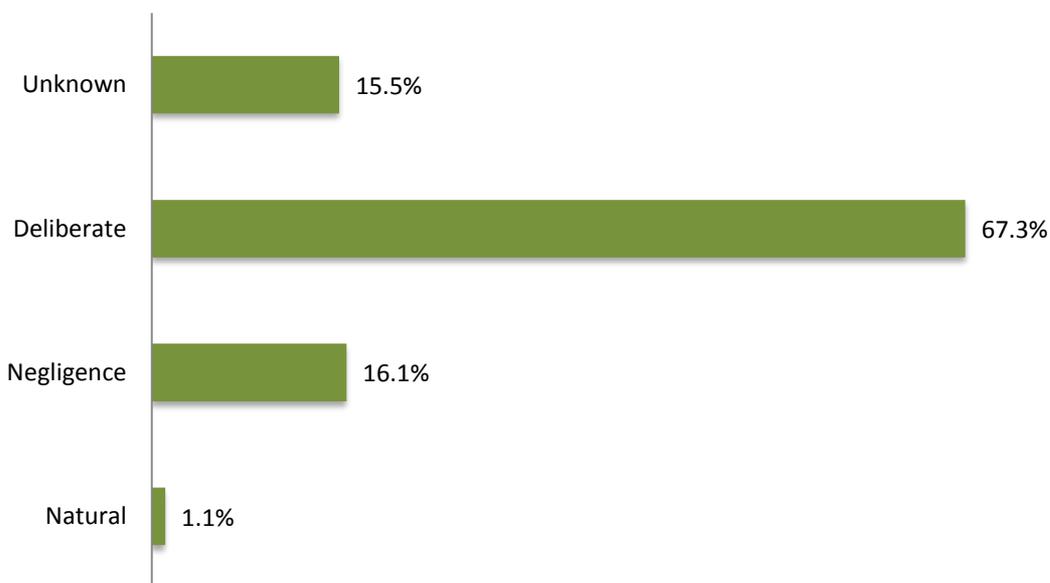
3.3.1 Assessing forest fire crime

The Italian Forest Corp, in fighting forest fire crimes, has given impetus to both the centralized and decentralized organizations through the NIAB. This was established in 2000 by the General Inspectorate, which operates on the national territory, with the exception of the regions with special statute and the autonomous provinces (Sicilia, Sardegna, Valle d'Aosta, Trentino-Alto Adige, Friuli Venezia Giulia). The NIAB is responsible for coordination and direction of information investigations and analysis in relation to forest fires and provides

operational, investigative and logistical support to the territorial offices of the Italian Forest Corp, also through the research of evidence collected at the scene of fires and the analysis of residues of explosives and triggers.

Knowing forest fire causes is crucial in understanding the extent of the crime. The cause analysis performed in this section is based on the causes attributed by the Italian Forestry Corp for statistical surveys of forest fires. This statistic, therefore, does not include details of the events, which occurred in the autonomous regions and provinces. With the exclusion of the most obvious cases, attributing causes of fire is a very complex process that is the outcome of a series of analyses carried out on the site of the event and subsequently, through investigative activities of the judicial police. In this context, figure 9 below shows forest fires and related causes that occurred in Italy in 2012. Particularly, forest fire events due to deliberate actions account for 67.3%, those due to negligent behaviors are about 16%, while naturally occurring forest fires are quite marginal (1%).

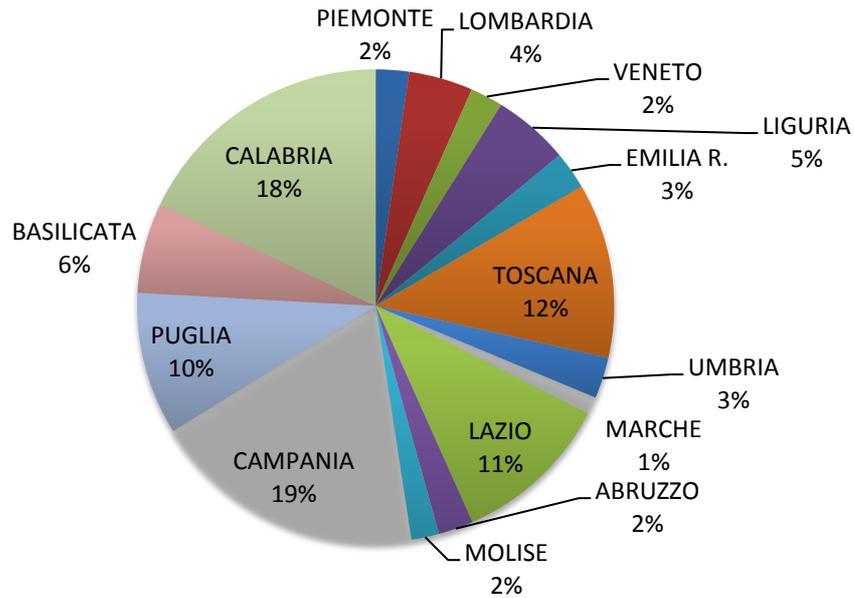
Figure 9. Forest fire by causes in Italy (2012).



Source: authors' elaboration from Italian Forest Corp data

The analysis of the number of forest fire crimes by region (Figure 10), in 2012, clearly shows that the most affected regions were Campania with 972 fire events (19% of the national amount), followed by Calabria (18%), Toscana (12%), Lazio (11%) and Puglia (10%): these regions concentrate almost 60% of the total forest fire crimes at national level, amounting to 3,622 events.

Figure 10. Forest fire crime in Italy (2012) by regions



Source: authors' elaboration from Italian Forest Corp data

3.4 Environmental impact

As already emphasized, a possible way to quantify the environmental impact of fire crime is to assess how much area has been burnt because of it. To this end, we are able to determine, on average per year, how much area has been burnt owing to forest fires during the last decade. By combining such information with forest fire causes (i.e. deliberate or negligent) we can try to quantify the environmental impact. Hence,

$$\text{Environmental Impact} = \text{Average Burnt Area per fire (ha)} * \text{Number of fire crimes}$$

Table 4 below displays in detail the number of fire crimes that occurred in Italy over the decade 2003-2012. Overall, the total environmental impact recorded in the last decade amounts to 610,485.52 ha due to 48,105 events of arson.

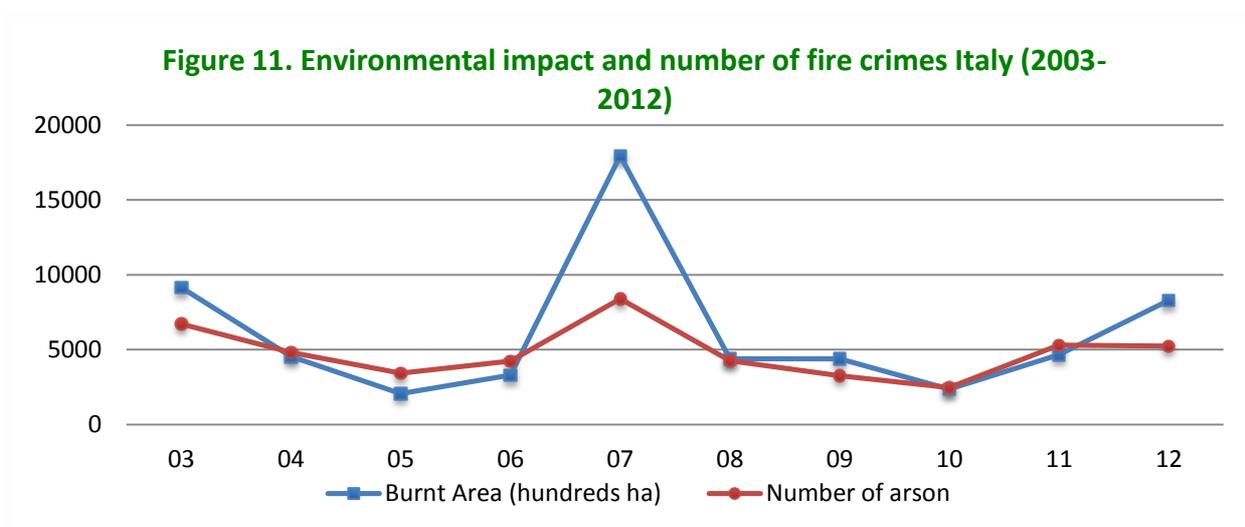
Table 4. Number of forest fire crimes, average burnt area and environmental impact in Italy over the last decade

| Years | Number of fire crimes | Average Burnt Area (ha) | Environmental Impact (ha) | Fire Severity |
|-------|-----------------------|-------------------------|---------------------------|---------------|
| 2003 | 6,720 | 13.6 | 91,392 | 46% |
| 2004 | 4,823 | 9.4 | 45,336.2 | 52% |
| 2005 | 3,422 | 6.01 | 20,566.22 | 53% |
| 2006 | 4,238 | 7.8 | 33,056.4 | 54% |

| | | | | |
|---------|---------|------|------------|-----|
| 2007 | 8,384 | 21.4 | 1,794,17.6 | 61% |
| 2008 | 4,250 | 10.3 | 43,775 | 54% |
| 2009 | 3,251 | 13.5 | 43,888.5 | 52% |
| 2010 | 2,475 | 9.52 | 23,562 | 51% |
| 2011 | 5,296 | 8.8 | 46,604.8 | 61% |
| 2012 | 5,246 | 15.8 | 82,886.8 | 68% |
| Average | 4,810.5 | 11.6 | 61,058.55 | 55% |
| Total | 48,105 | | 610,485.52 | |

Source: authors' elaboration from Italian Forest Corp data

Figure 11 below depicts the progression of the number of fire crimes and related total burnt area per year in Italy over the last decade (2003-2012). In particular, 2012 exhibits a local maximum for the environmental impact, being overpassed in previous years only by the critical 2007 fire seasons. In line with other Mediterranean countries, in 2012 the number of fire crimes decreased but, at the same time, the overall burnt area increased. According to Montealegre (2014), in this framework, fire events resulted to be clearly much more destructive than in the past years since 68% of them represent large fire (>50 ha).



Source: authors' elaboration from Italian Forest Corp data

In Italy, forest fire events are widespread throughout the country, however they assume different configurations moving from one region to another given the broad geographical heterogeneity. The latest data from NIAB reporting system are those for the year 2012, which were elaborated and published in 2013. Table 5 summarizes the extent of the forest fire crime that occurred in each Italian region in 2012 (excluding autonomous regions and provinces) taking into account the number of forest fire crimes, average burnt area and environmental impact. Moreover, in order to have a comparable indicator we link environmental impact to each

region's total surface.

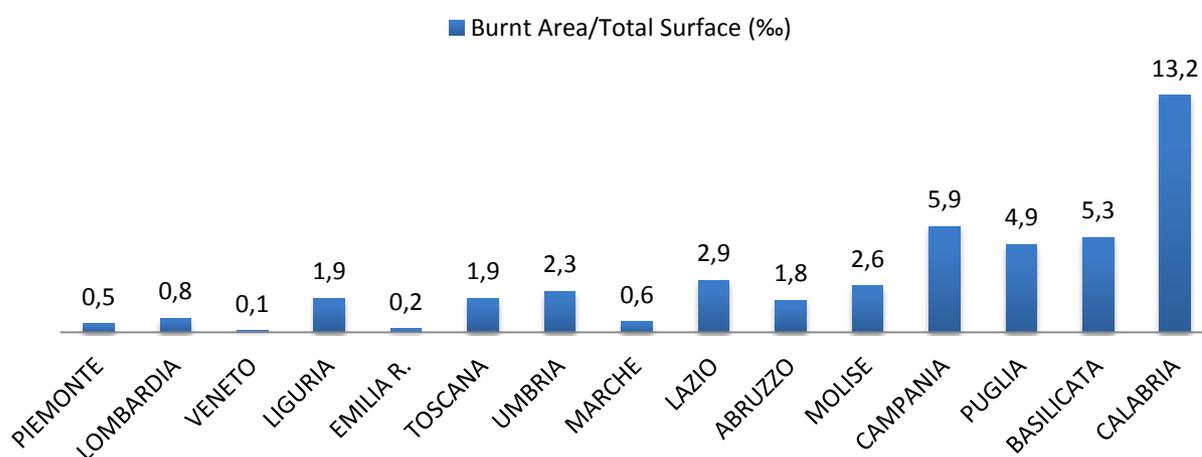
Table 5. Number of forest fire crimes, average burnt area and environmental impact in Italy in 2012

| Region | Number of fire crime | Average Burnt Area (ha) | Environmental Impact (ha) | E. Impact/Total Surface (‰) |
|------------|----------------------|-------------------------|---------------------------|-----------------------------|
| PIEMONTE | 118 | 8.3 | 979.4 | 0.5 |
| LOMBARDIA | 228 | 5.1 | 1,162.8 | 0.8 |
| VENETO | 117 | 0.9 | 105.3 | 0.1 |
| LIGURIA | 272 | 3.7 | 1,006.4 | 1.9 |
| EMILIA R. | 135 | 3.0 | 405 | 0.2 |
| TOSCANA | 627 | 3.7 | 2,319.9 | 1.9 |
| UMBRIA | 147 | 13.2 | 1,940.4 | 2.3 |
| MARCHE | 62 | 3.9 | 241.8 | 0.6 |
| LAZIO | 568 | 11.3 | 6,418.4 | 2.9 |
| ABRUZZO | 125 | 9.9 | 1,237.5 | 1.8 |
| MOLISE | 98 | 6.6 | 646.8 | 2.6 |
| CAMPANIA | 972 | 6.8 | 6,609.6 | 5.9 |
| PUGLIA | 512 | 14.8 | 7,557.6 | 4.9 |
| BASILICATA | 322 | 17.9 | 5,763.8 | 5.3 |
| CALABRIA | 943 | 21.1 | 19,897.3 | 13.2 |

Source: authors' elaboration from Italian Forest Corp data

In Table 6 it is possible to observe that the regions with the highest number of fire crimes were Campania (27% of the national amount, corresponding to 972 fires) whose burnt area is about 6,600 ha, Calabria (21%) with 943 fires and an environmental impact amounting to 19,897 ha and Puglia (15% of the total, equal to 512 fires) with an affected area equivalent to 7,557 ha. It is worth noting that the environmental impact arising from fire crimes seems to be quite negligible in some north Italian regions. In particular, during 2012, intentional fires burnt 0,1% (Veneto) and 0,2% (Emilia Romagna) of the total regional surface (see figure 12).

Figure 12. Extent of the environmental impact considering regional total surface



Source: authors' elaboration from Italian Forest Corp data

The environmental impact of forest fire crime seems to be extremely concerning in those areas designed for the protection and maintenance of the ecological diversity through legal or other effective measures. Protected areas, including any state forest, national park and protected public land, are increasingly threatened by forest fire in Italy. Fortunately, from the estimates derived so far about the environmental impact of forest fire crimes, latest data from NIAB allow us to exactly quantify the magnitude of the environmental impact on protected areas, with regard to the ordinary statute regions served by Italian Forest Corp, by summing the burnt area (ha) arising from every single fire crime event. In particular, in 2012, the occurrence of forest fires in protected areas such as national parks and public protected land totaled 793 fire crimes that covered about 8,864 hectares (Table 6).

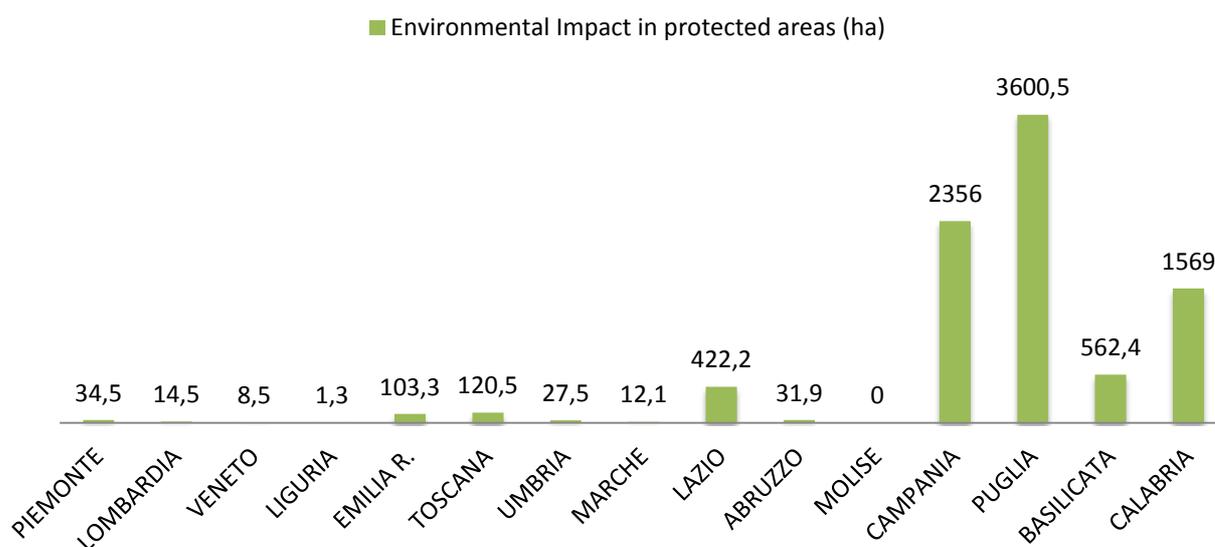
Table 6. Number of forest fire crimes and environmental impacts in protected areas in Italy in 2012

| Region | Number of fire crimes | National Parks | Other public protected land | Environmental Impact |
|---------------|------------------------------|-----------------------|------------------------------------|-----------------------------|
| PIEMONTE | 6 | - | 6 | 34.5 |
| LOMBARDIA | 18 | 1 | 17 | 14.5 |
| VENETO | 18 | 4 | 14 | 8.5 |
| LIGURIA | 6 | 3 | 3 | 1.3 |
| EMILIA R. | 18 | 2 | 16 | 103.3 |
| TOSCANA | 28 | 3 | 25 | 120.5 |
| UMBRIA | 8 | 2 | 6 | 27.5 |
| MARCHE | 6 | 2 | 4 | 12.1 |
| LAZIO | 55 | 4 | 51 | 422.2 |
| ABRUZZO | 8 | 5 | 3 | 31.9 |
| MOLISE | 2 | 1 | 1 | 0 |
| CAMPANIA | 303 | 171 | 132 | 2,356 |
| PUGLIA | 186 | 99 | 87 | 3,600.5 |
| BASILICATA | 51 | 42 | 9 | 562.4 |
| CALABRIA | 80 | 70 | 10 | 1,569 |
| TOTALE | 793 | 409 | 384 | 8,864.2 |

Source: authors' elaboration from Italian Forest Corp data

During 2012, the most affected regions in terms of protected area burnt by fire crimes were Campania and Puglia. The number of fires were 303 in Campania with a total environmental impact of 2,356 ha, and 186 in Puglia, where the environmental impact amounts to 3,600.5 ha, 2,022.2 of which were in national parks. In figure 13, it is worth noting the huge difference between northern and southern regions: Campania, Puglia, Basilicata and Calabria total about 95% of the whole national environmental impact in protected area due to fire crime.

Figure 13. Environmental impact in protected areas (2012)



Source: authors' elaboration from Italian Forest Corp data

3.5 Health impact

To estimate the health impacts of forest fires in Italy, two variables are taken into account; namely number of deaths and injured people. Table 7 below displays in detail the number of victims of forest fires in Italy over the decade 2003-2012, disregarding fire causes. Overall, the loss of human lives amounts to 55 people with 442 injured. The most dramatic season was recorded in 2007 with 23 deaths and 26 injured.

Table 7: Forest fire victims in Italy (2003-2012)

| Years | Injured | Deaths |
|-------|---------|--------|
| 2003 | 75 | 7 |
| 2004 | 35 | 2 |
| 2005 | 43 | 3 |
| 2006 | 17 | 1 |
| 2007 | 26 | 23 |
| 2008 | 30 | 4 |
| 2009 | 12 | 4 |
| 2010 | 55 | 3 |
| 2011 | 92 | 4 |
| 2012 | 57 | 4 |
| Total | 442 | 55 |

Source: authors' elaboration from Italian Forest Corp data

Table 8 below indicates number of forest fire crime victims (injured and deaths) recorded in Italy during 2012 with regard to the ordinary regions.

Table 8: Fire crime victims in Italy by region (2012)

| Region | Number of fire crimes | Injured | Deaths |
|------------|-----------------------|---------|--------|
| PIEMONTE | 118 | 2 | 1 |
| LOMBARDIA | 228 | 3 | - |
| VENETO | 117 | - | - |
| LIGURIA | 272 | 2 | - |
| EMILIA R. | 135 | 2 | 1 |
| TOSCANA | 627 | 5 | - |
| UMBRIA | 147 | 4 | - |
| MARCHE | 62 | 1 | - |
| LAZIO | 568 | 2 | - |
| ABRUZZO | 125 | 12 | - |
| MOLISE | 98 | 1 | - |
| CAMPANIA | 972 | 9 | 1 |
| PUGLIA | 512 | 2 | - |
| BASILICATA | 322 | 5 | - |
| CALABRIA | 943 | 3 | 1 |
| Total | | 53 | 4 |

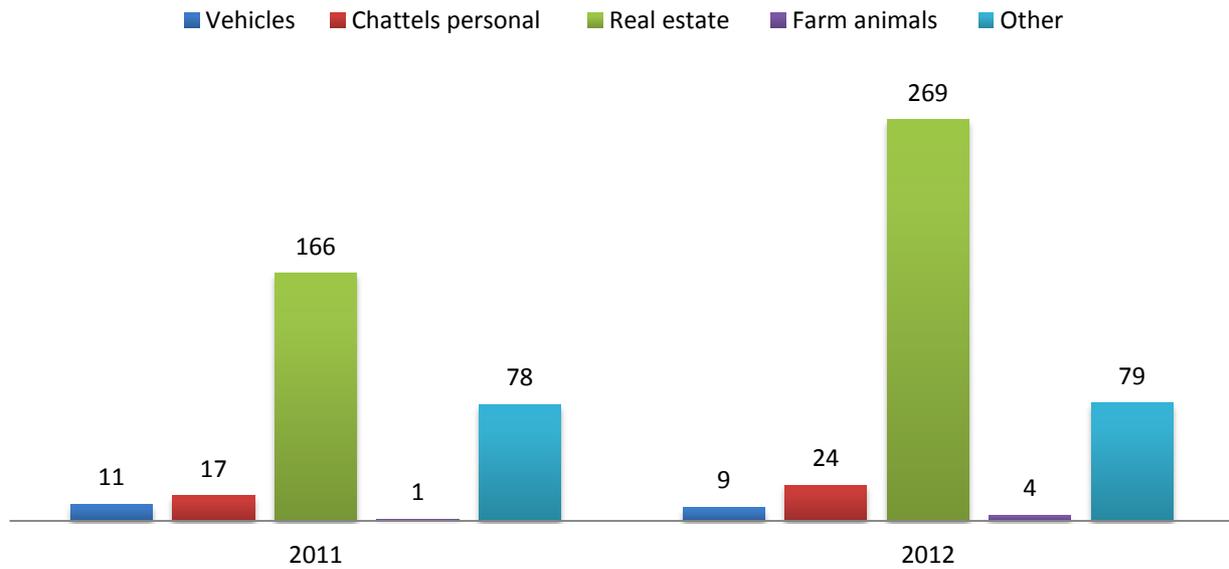
Source: authors' elaboration from Italian Forest Corp data

The number of victims of forest fire crime, in 2012, concerning only the ordinary statute regions served by the Italian Forest Corp, was slightly lower compared to other years: there were 4 deaths and 53 injured, the latter probably underestimated, since it refers only to cases reported in the official survey of the Italian Forest Corp. The deaths occurred in Piemonte, Emilia Romagna, Campania and Calabria, in the provinces of Torino, Modena, Napoli and Cosenza. While, the regions that have a greater number of injured are in order: Campania (14), Toscana (8), Umbria (7), Liguria and Basilicata (5), Calabria (3).

3.6 Material impact

To assess the material impact of forest fire crime, relying on Italian Forest Corp data, we consider five main categories of possible damages arising from fire events: (i) *vehicles*; (ii) *chattels personal*; (iii) *real estate*; (iv) *farm animals* or other damages. The available data allow us, in contrast to other investigated impacts, to quantify material impacts, both at country and region level, only for the years 2011-2012. Figure 14 below shows how many forest fires gave rise to such impacts.

Figure 14. Material Impacts (2011-2012)



Source: authors' elaboration from Italian Forest Corp data

Although the number of fire crimes that occurred in the country in 2012 (5,246) decreased with respect to 2011 (5,296), the total number of fire events that caused material impacts on the aforementioned categories significantly increased from 273 to 385 fires. This is particularly evident with regard to real estate, which was much more affected by fire crimes (166 in 2011 vs. 269 in 2012).

Table 9 below displays in detail the extent of the economic and material impact in 2012, looking at the different categories of affected goods for each ordinary statute region.

Table 9. Number of fire crimes causing material impact by regions (2012)

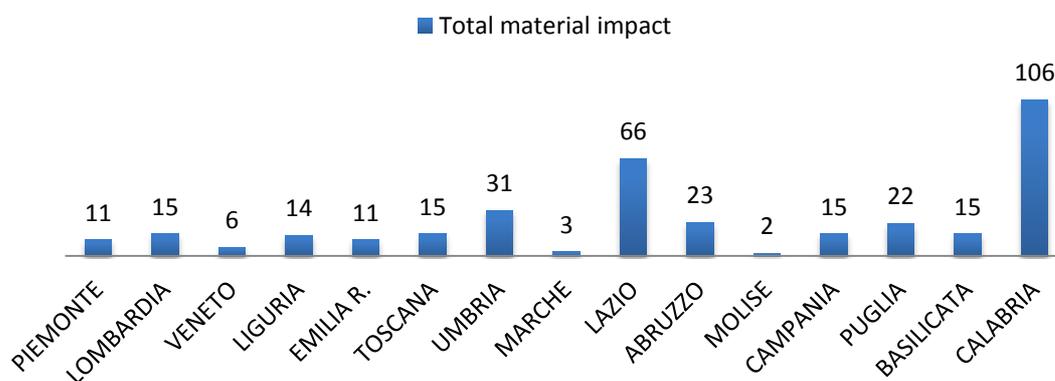
| Region | Vehicles | Chattels Personal | Real Estate | Farm Animals | Other |
|-----------|----------|-------------------|-------------|--------------|-------|
| PIEMONTE | 7 | 2 | 2 | - | - |
| LOMBARDIA | 1 | 1 | 12 | 16 | 1 |
| VENETO | - | 3 | 3 | - | 1 |
| LIGURIA | 1 | 3 | 5 | - | 5 |
| EMILIA R. | - | 2 | 9 | 12 | - |
| TOSCANA | 1 | 2 | 3 | 2 | 7 |
| UMBRIA | - | 1 | 27 | 1 | 3 |
| MARCHE | - | - | 1 | 1 | 2 |
| LAZIO | - | 11 | 55 | - | 1 |
| ABRUZZO | - | - | 15 | - | 8 |
| MOLISE | 1 | 1 | - | - | - |

| | | | | | |
|------------|---|---|----|----|----|
| CAMPANIA | 2 | 1 | 27 | 12 | 4 |
| PUGLIA | 1 | 4 | 19 | 1 | 5 |
| BASILICATA | - | 2 | 6 | 1 | 6 |
| CALABRIA | 1 | 2 | 88 | 7 | 15 |

Source: authors' elaboration from Italian Forest Corp data

As it is possible to see in figure 15, the regions particularly affected are Calabria and, surprisingly, Lazio: in Calabria as many as 106 fire crimes led to economic damages, mainly on real estates (88); in Lazio fire crime events totaled 66, 11 of which destroyed personal chattels. Conversely, less affected regions were Marche and Molise, with respectively 3 and 2 fires that gave rise to material consequences during 2012.

Figure 15. Number of fire crimes with material impacts



Source: authors' elaboration from Italian Forest Corp data

3.7 Investigation and enforcement activities in Italy

In the fight against fire, which every year also devastates parks and natural reserves, the Italian Forest Corp has started an operational activity that could soon be effective. In fact, the solution to the issue does not lie in dispensing punishment, which in 2000 was punishable with 10 years prison, rather, it is "a matter of civic-mindedness, of sharing the will to protect the common good: the forest."

Fires are very costly, both for the environment and for the State. Every year, each Italian taxpayer unwittingly invests about € 60-70 of his/her taxes in the protection system for the active fight against forest fires, which is a significant social cost. For a year now, the Italian Forest Corp has undertaken an initiative to charge those who, negligently or willfully, set fire to our

beautiful forests. The charge would correspond to the cost of the environmental damage, which could be really expensive.

Evaluating the environmental damage, a fire of 40-50 acres of forest can reach figures greater than € 250,000. The exact amount depends on the quality of the forest. Moreover, there is also a cost related to the mission to contain the fire. The Canadair and the helicopter have a considerable per hour cost and the fire tanker truck is expensive as well. A fire extinguished with the involvement of an airplane, can easily cost more than € 30,000 which is only the expense for the extinction.

Quantifying the value of the forest patrimony in the country is not easy. As a matter of fact, the protection of forests and the safeguard of environmental integrity coincide with the protection of human life on the planet and to attribute an economic value to this is difficult and complex. In order to deal effectively with forest fire crimes it is necessary to adopt an integrated investigative approach, which entails various types of analysis, including: (i) analysis of the causes of the fires, (ii) analysis and investigative psychology, (iii) criminological analysis (profiling), and (iv) socio-economic analysis, but also an interdepartmental approach involving the Italian Forest Corp, the intelligence services, local authorities, the National Body of Fire Brigades, the Police, and the Civil Protection services.

The Italian Forest Corp, in fighting against fire crimes, has given impetus to both the central organization and outstations, through the NIAB. This was established in 2000 by the Inspectorate general and operates throughout the national territory, with the exception of the regions with special statutes and the autonomous provinces. The NIAB is responsible for coordination and direction of information investigation and analysis in relation to forest fires and provides operational, investigative and logistical support to the territorial offices of the Italian Forest Corp, also through its research of evidence collected at the scene of fires and the analysis of residues of explosives and triggers (JRC Technical Report, 2012). Article 423-bis of Italian Penal Code (Incendio boschivo), introduced by Law 353/2000, has in recent years improved the assessment of the reasons underlying the wildfires in order to understand and analyze in depth the phenomenon of forest fires and, consequently, to introduce effective legal instruments for carrying out the investigations.

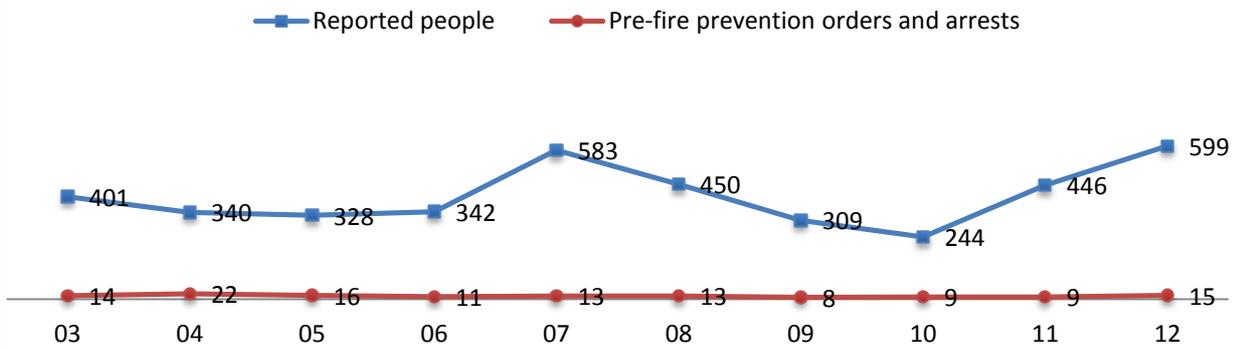
Actions against forest fire offences undertaken by the territorial Italian Forest Corp in 2012, made it possible to report 614 people to the judicial authority, of which 563 were for negligent fires and 51 for arson (table 10). Of these, 15 people were arrested, pursuant to custodial measures for arson, while 579 were released on caution (table below).

Table 10: Number of forest fire crime complaints in 2012

| Cause | Numbers | Percentage |
|--------------|------------|------------|
| Negligence | 563 | 91.7 |
| Deliberate | 51 | 8.3 |
| TOTAL | 614 | 100 |

Source: authors' elaboration from Italian Forest Corp data

Figure 16. Number of reported people and pre-fire prevention orders in Italy (2003-2012)

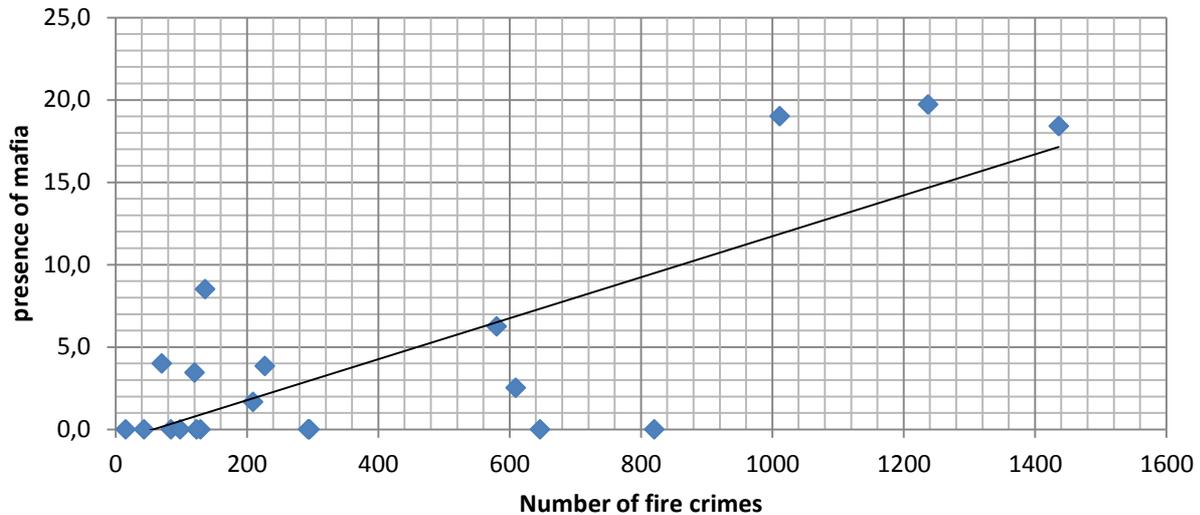


Source: authors' elaboration from Italian Forest Corp data

In total, over the period 2000-2012, over 5,000 people were reported to the judicial authority for forest fire offences, of which 164 were arrested in the act or were subjected to pre-fire detention orders. Analyzing the judgments issued by the judicial authority and collected by NIAB since 2000, it is revealed that the judicial process ended with the conviction of responsible in 45% of the reported cases, while the remaining with absolution (13%) or archiving (42%).

The Italian environmental group Legambiente (2010) believes that more than half of all Italy's fires are started deliberately, whether by organized crime, building speculators or farmers seeking more land to cultivate. It is interesting to note, from a more in depth analysis based on our estimation using 2012 data, how evidence has emerged of a positive correlation between organized crime (i.e., mafia-like organizations) and number of fire crimes (Figure 17). The grip of organized crime seems to be stronger in several of Italy's southern regions, right where the government's ability to enforce the law there is correspondingly weaker.

Figure 17. Correlation between organized crime and number of fire crimes



Source: authors' elaboration and estimation.

However, according to the Italian Forestry Corp (Forest Fires Report – various years) mafia-like organizations have nothing or very little to do with forest fire crimes. Organized criminals responsible for deliberate fires can represent isolated and sporadic actions. The most important motives behind deliberate fires in Italy (Tedim et al., 2014) are: (i) profit activities to obtain goods, jobs or even money (e.g. hunting products in areas scorched by fire passage such as mushrooms and wild asparagus; vegetation burning to earn agricultural land; fire caused with the intent of being included in fire-fighting crews), (ii) social and interpersonal tensions (e.g. hunting conflicts, ownership controversies), (iii) negligent behaviors (e.g. fire-crackers and bottle-rockets), and (iv) fire as a means of protest against public powers (e.g. retaliation against public administration and protest of seasonal fire-fighters).

In fact, the marginal role of mafia-like organizations in the context of forest fire crimes has been investigated by the Italian Forestry Corp, which conducted, on behalf of the government, an exploratory investigation on the causes of fires in Italy since 2001. This allowed, for the first time, studying the causes of forest fires and working on their classification in an organic and systematic manner, nationwide. To this end, it has been used as a scientific method for the detection of the causes of the onset of the forest fire (called Method of Physical Evidence)⁵. The

⁵ This method shall be understood as a procedure, a technique, a sequence of steps that allows us to reconstruct the evolution of a fire through the study of its behavior and the traces it left up to the determination of the point of origin, and therefore to the identification of the cause of the fire, of its initiators and its reasons. The method is characterized by a complex procedure, which unfolds in several stages: i) determination of the geometry of the fire; ii) reconstruction of the evolution of the fire; iii) the definition of the path of propagation and detection of the

result is that, compared to a negligible percentage of natural and accidental causes (around 1.6%), there is a significant figure relative to fires caused by people: among these fires, the large majority (almost 60% of the total) seemed to be deliberate. In particular:

- In 70.4 % of cases the motivation for the arsonist to start a fire was the pursuit of financial gain;
- In 25% of cases it is *resentment* towards measures enacted by the authority that manages the burnt areas (e.g. protected areas);
- The remaining 4.6% of undefined deliberate causes are definitely related to voluntary acts, but the aim pursued by the author cannot be classified with certainty, for the lack of precise and objective evidence.

4 The monetary impact of fire crime

Forest fires represent a calamity that significantly affects wild-lands worldwide with its related impacts. Nevertheless, there is relatively little information on the actual monetary damage resulting from forest fires. An appropriate monetary analysis concerning forest fires could represent an effective instrument to prevent and mitigate the loss of biodiversity. It is crucial to justify and to select the most effective forest fire management measure in order to minimize the different impacts of wildfires as much as possible.

In the literature, the analysis on the estimation of the damage is mainly focused on private goods. However, recently, some authors have paid specific attention to damages from fires in wooded areas, bringing forth some case studies, which hardly account for the complexity of the issue. Very few are the studies that focus on the public profile of the damage (see among others Marangon and Gottardo, 2001 and Valesse et al., 2011), looking at estimating the environmental damage of this delicate issue.

As previously emphasized in the methodological section, the Italian Academy of Forest Fire and the Italian Forest Corp (2007) provided a methodological framework for the economic monetization of specific impacts arising from wildfire. In particular, according to this study (Ciancio et al., 2007), the total impact is divided into three components: *extinction cost*, *environmental damage*, and *external damage*. The estimate of such components is based on the calculation of the Total Economic Value (TEV) of the forest areas in question employing

ignition area; iv) search for the ignition point; v) search for the evidence relating to the cause; vi) comparison between physical evidence and witnesses' statements; and vii) classification of the cause of the fire.

different approaches, analytics or synthetics, based on the characteristics of the forest fire (i.e. fire size, type of fire - wooded or not wooded, etc.). By definition, the damage arising from forest fires is peculiar because of its mixed nature of forest as goods, of which the concurrence of both public and private damage occurs. In addition, there are also other peculiar aspects connected with the presence of multiple and joint productions, the wide time span between the initiation and the use of the stand, the different structure of the stands (on the base of the age, articulated, etc.) as well as the possible existence of complementary relations between the areas affected and those not affected by the fire, and so on and so forth.

For the sake of clarity, in the following sections, we present three different case studies, concerning the estimation of the monetary impact of forest fires, as examples of different methodological approaches that have been considered reliable by the Italian courts in criminal proceedings.

4.1 The case of the Morfasso forest fire in Favale

The forest fire considered here took place on the 22nd and 23rd July 2010. It destroyed over 8.5 ha of woods above Mignano dyke (Piacenza). It was a large-scale fire and required the intervention of fire fighter helicopters and Canadair airplanes for its suppression. The Piacenza Provincial Command of the Italian Forest Corp reported, as the alleged responsible authority for the fire, two workers from Romania who were employed in an agricultural cooperative. They were performing forest-cleaning operations on behalf of the Mountain Community Valnure and Valdarda.

During the investigations, which were carried out immediately after the fire through the use of the Physical Evidence Method (M.E.F.), the Italian Forest Corp found traces of several fires along the path that ran along the forest. One of these that had been lit on July 22nd, when a strong wind was blowing, was not adequately supervised. It was determined that the flames started from there and in no time invaded the slopes expanding toward the village of Favale, which fortunately was not reached by the flames.

The essential elements that characterized the fire are summarized in table 11 below:

Table 11. Favale of Morfasso forest fire

| | |
|---------------------|----------------|
| <i>Region</i> | Emilia Romagna |
| <i>Province</i> | Piacenza |
| <i>Municipality</i> | Morfasso |

| | |
|----------------------------------|--|
| <i>AIBFN</i> | N°3/2010/3775 |
| <i>Affected Area</i> | 8.5 ha |
| <i>Fire cause</i> | Negligence |
| <i>Type of affected forest</i> | oaks, ash trees, manna ashes and black pine forest |
| <i>Beginning of fire</i> | 22 rd July 2010 |
| <i>End of fire</i> | 23 rd July 2010 |
| <i>Utilized vehicles</i> | 2 aircrafts, 6 extinguishing trucks |
| <i>Material damages</i> | None |
| <i>Injured and / or deceased</i> | None |

Source: authors' elaboration from Italian Forest Corp data

4.1.1 Estimation method

The estimate is based on the calculation of the TEV of the forest areas under investigation following the analytical approach and looking at the three components of the monetary impact: *fire extinction costs, environmental damage, and external damage.*

- **Fire extinction costs** (or suppression costs) are costs relating to machines and personnel's equipment used during the operation of active fire fighting. According to the *AIBFN* report N°3/2010/3775 of the Italian Forest Corp, we are able to quantify the total cost of intervention. Particularly, two Canadair airplanes were used in the fire fighting activities on the 22nd and 23rd July 2010, in Favale of Morfasso forest fire. One CAN 20 for eight hours and dropping of fire suppressing foam eleven times for a duration of one minute and a one time use of fire retardant; one CAN 2 for seven hours and forty six minutes, dropping fire suppressing foam eleven times and fire retardant one time. This totals fifteen hours and forty-seven minutes, twenty-two fire suppressing foam drops and two fire retardant drops. Taking into account the duration of the extinction operations and the cost of the equipment used the total cost of the intervention is € **100,504.54** (Table 12).

Table 12. Favale of Morfasso forest fire extinction costs

| Authority working to suppress the fire | Overtime hours | Cost of the missions | Fuel/ Extinguishing or retardant agents | Hourly cost for flight/ rent/ labor |
|--|-------------------|----------------------|---|-------------------------------------|
| Civil Protection Department (COAU ⁶) | | | € 5,233.00 | € 68,445.58 |
| Italian Forest Corp (P.C. ⁷ Provincial Command) | € 1,393.34 | € 244.64 | € 142.38 | |
| Piacenza's Fire fighters | € 383.33 | | € 196.96 | |
| Civil Protection AIB Volunteers (P.C.) | | € 561.00 | € 632.31 | |
| Morfasso's Municipality | | | | € 7,272.00 |
| VV.FF. ⁸ Bologna Flight Department | | | | € 16,000.00 |
| TOTAL | € 1,776.67 | € 805.64 | € 6,204.65 | € 100,504.54⁹ |

Source: authors' elaboration from Italian Forest Corp data

- **Environmental damage:** a conventional approach for an analytical estimation of the environmental damage can be made by determining the cost of reconstruction or restoration. The estimation criterion is based on the assumption that an asset is worth (at least) what it costs. The damage was evaluated through an analytical approach based on two functions of the forest: (i) *Wood production loss* (PPL) and (ii) *Decreased hunting activity* (DAven). The estimate of the PPL equals the sum of the

⁶ COAU = Unified Aircraft Operative Center

⁷ P.C.= Piacenza

⁸ VV.FF. = Fire fighters

⁹ The ordinary cost of the Institutional Staff is not included.

economic damages (DE) suffered by the coppice forest (c), the tree trunk forest (a), and the mass of the harvested timber, therefore

$$PPL = DEc + DEa + DEle$$

The values are given by the following functions:

For the oak coppice:

$$DEc = Sup * Vol * \left(\frac{Pimp - Cte}{(1 + r)^n} \right) = 6.7425 * 13.82 * \frac{(85 - 20)}{(1 + 0.03)^{15}} = \text{€ } \mathbf{6056.79}$$

where *DEc* is the Economic damage derived from the loss of firewood of the coppice forest, *Sup* is the coppice area affected by the fire (in hectares), *Vol* represents the volume of marketable firewood lost due to the fire (in m³/ha), *Pimp* represents the average price of the pallet, *Cte* are the cutting and skidding costs, *r* is the discount rate and *n* represents the remaining years to reach the age of customary round.

For the black pine tree trunk

$$DEc = Sup * Vol * \left(\frac{Pimp - Cte}{(1 + r)^n} \right) = 1.4635 * 48.32 * \frac{(33,60 - 30,00)}{(1 + 0.03)^{15}} = \text{€ } \mathbf{396.60}$$

For the oak firewood

The damage loss is quantified in:

$$DEle = (Mt * Vimpr) + (Mp * Vmac) = (117.86 * 7,5) + (23.17 * 6.5) = \text{€ } \mathbf{1034.55}$$

where *Mt* represents the mass in quintals of lost wood; *Vimpr* is the value of the piled wood in the accessible area on the forest track; *Mp* represents the mass in quintals of the root sprouts compromised by the fire and *Vmac* is the stumpage value, that is cutting and skidding costs before taxes.

The total environmental damage from the loss of timber production amounts to:

$$PPL = DEc + DEa + DEle = \mathbf{6056.79 + 396.60 + 1034.55 = \text{€ } 7487.94}$$

The second forest function to evaluate the environmental damage is the *decreased hunting activity* (DAven) (ungulates and local fauna). Given that the Law 353/2000 article 10 paragraph 1 prohibits hunting for 10 years in forest areas where topsoil was crossed by fire, the damage can be estimated as the sum of ten yearly values of the annual hunting function, at the discount rate of 3%.

The calculation function is therefore:

$$DAven = Sup * R * \frac{(1 * r)^{10} - 1}{r * (1 * r)^{10}} = 8.2814 * 7.45 * 8.5302 = \text{€ } 526.28$$

where *Sup* is the area crossed by the fire and excluded from the hunting activity (in hectares); *R* represents yield per unit of the hunting area for the ATC PC 7 (Piacenza's hunting zone) (euro/hectare).

- **Extraordinary external damages.** The estimate of extraordinary external damages only takes into account the cost of reconstruction of the destroyed and damaged topsoil. As a matter of fact, there are no infrastructures or buildings in the area, nor has damage occurred to people or mechanical means. The current price list for the regional forest works' public initiative (Resolution 2085 of 20th December 2007) was taken as a reference for the typologies of forest works to be designed and implemented. Unit prices (before taxes) are applied in relation to the damaged areas and to the level of damage calculated according to the Method of the Observable Effects. The payment of damages for the cost of forest regeneration is quantifiable as follows:

$$Dcr = (CR * Sc * LD) + (Cte + Sa) + (Ctab * S) = (2702.90 * 6.7425 * 0.09) + (4157.32 * 1.4635) + (102.36 * 8.2814) = \text{€ } 8572.10$$

Where *CR* is the cost of regeneration of the oak coppice forest through selective thinning by elimination of damaged, cut off, decaying or dried root sprouts, including cutting off branches, splitting wood, and piling of resulting material, cleaning up the adjacent outer and inner tracks (item 41 regional price list) (euro/hectare); *Sc* represents the Coppice Area; *LD* is the level of damage, estimated by the ratio between mass loss (13.82 m³/ha) and existing medium mass (149 m³/ha), by applying the Method of the Observable Effects similarly to the estimate of the economic damage for loss of firewood (DEc); *Cte* is the cost for pine cutting and skidding, 20-30 cm in diameter, including branch pruning, wood sawing, piling, transportation of the wood to the pallets and removal of the branches by using tractors (items 45 + 47 + 49 of the regional price list). In relation to the mass loss of 48.32 m³ in tree trunk, and to the average volume - m³ 0.327/plant, the dead standing or cut plants to be removed are estimated at €148/hectare; *Ctab* is the cost of supply and installation of warning signs (40x35 cm) on wooden poles (estimated 3/hectare) (item 76 of the regional price list) (in euro/hectare); *S* is the total area of the fire to be posted with no hunting signs (hectares).

After having analytically estimated the three components of the forest fire monetary impact we are able to exactly quantify it. To this end, the table below (13) shows a summary of the monetary estimated impact for the Morfasso forest fire that occurred on July 22nd and 23rd, 2010:

Table 13. Summary of the monetary impacts

| | |
|--|---------------------|
| Costs for fire suppression | € 100,504.54 |
| Environmental damage (services and goods) | € 8,012.22 |
| Extraordinary external damage (cost for forest regeneration) | € 8,572.10 |
| Total monetary impact | € 117,088.86 |

Source: authors' elaboration from Italian Forest Corp data

4.2 The case of the Maracallo forest fire

For a better understanding of the proposed methodology in assessing the monetary damage from forest fire (Ciancio et al., 2007) we present a second case study concerning the fire event that occurred in Monte della Croce, municipality of Maracallo (Va) on April 22nd, 2011. Such a case study relies on the approach of standard costs (personal and related equipment) for the assessment on the extinction costs and the environmental damage. Moreover, the extraordinary external damages were not considered because the forest fire did not affect physical assets or people's health. The main points of information about the investigated fire are listed in table 14 below:

Table 14. Maracallo forest fire

| | |
|---------------------------------|-------------------|
| <i>Region</i> | Lombardia |
| <i>Province</i> | Varese |
| <i>Municipality</i> | Maracallo |
| <i>AIBFN</i> | N°4/2011/7757 |
| <i>Affected area</i> | 1.49 ha |
| <i>Fire cause</i> | Negligence |
| <i>Type of forest affected</i> | Chestnut and pine |
| <i>Beginning of fire (time)</i> | 11:40 |

| | |
|----------------------------------|---------------------------------------|
| <i>End of fire (time)</i> | 18:00 |
| <i>Personnel intervened</i> | 2 CFS, 5 VV.FF. |
| <i>Voluntaries intervened</i> | 30 voluntary AIB |
| <i>Utilized vehicles</i> | 2 helicopters, 6 extinguishing trucks |
| <i>Material damages</i> | None |
| <i>Injured and / or deceased</i> | None |

4.2.1 Estimation method

Contrary to the previous case, given the limited fire size of the event, we considered it appropriate to employ parameterized models for synthetic quantifications, with reference to standard costs reported in the Italian Forest Corp technical document and/or from other official sources (D.s. 10-06-2011 n. 5256 Rural Development Program 2007- 2013 (Reg. CE 1968/2007) “Approval standard costs measure 226 Restoring forestry potential and introducing prevention actions”).

- **Fire extinction costs** can be estimated by knowing the average personnel cost per hour, the number of people employed, possibly divided into two categories (voluntary and contract fire-fighters) the duration of the extinction operations and the cost of the equipment used. Clearly, in the case of intervention of voluntary fire fighters, they should not be considered for the calculation of personnel costs, but must be included for the quantification of the cost of equipment. Usually, the Italian Forest Corp collects all this information for each fire event in Italy. Specifically, two helicopters Eurocopter Ecureuil AS 350 B3 and six extinction trucks were used in the fire fighting activities on 22nd April 2010 in the Maracallo forest fire. The table below shows in detail the equipment used and the related amount of time. Taking into account the duration of the extinction operations, the cost of the equipment used and the fire-fighters employed, the total cost of the intervention is **€ 21,307.98**.

| Table 15. Maracallo forest fire extinction costs (standard costs) | | | | | | |
|--|---------------|--------------|------------------------|--------------------------------|----------------------------------|--|
| Equipment and fire-fighters | Number | Hours | Hourly cost (€) | Adaptation rate (ISTAT) | Total monetary impact (€) | |
| Extinction trucks | 6 | 6 | 100 | 1.117 | 4,021.20 | |

| | | | | | |
|--------------------|---|---|-------|-------|--------------------|
| Helicopters | 2 | 4 | 2,000 | 1.000 | 16,000 |
| CFS Fire fighters | 2 | 6 | 18 | 1.117 | 402.12 |
| VVFF Fire fighters | 5 | 2 | 18 | 1.117 | 482.54 |
| TOTAL | | | | | € 21,307.98 |

Source: authors' elaboration from Italian Forest Corp data

- Environmental damage** is estimated using the conventional approach that focuses on the cost of reconstruction or restoration. Basically, the economic estimation of the environmental damage corresponds to the product of the following factors: *reconstruction cost*, *affected area* and *level of damage* due to the forest fire. The cost of reconstruction was determined with reference to the standard costs identified by costs measure 226 "*Restoring forestry potential and introducing prevention actions*" implemented by the Lombardy Region. In particular the initiative A.1.4.6 - *Recovery and reconstitution of forests damaged by natural disasters and fire*: Class 1 of operational difficulty, density from 701 to 900 plants/ha, damaged plants from 26% up to 50%; €11,903.33 per hectare (value refers to the year 2011). The forest fire affected area, determined through GPS, was exactly 1.49 ha. The level of damage, assessed on site by Italian Forest Fire experts, has been recognized equal to 50%. Finally, in order to take into account the time needed for the forest to reach pre-fire conditions we postponed the reconstruction cost of 20 years with a discount rate of 2%. The total amount of environmental damage amounts to €27,143.72, as shown in table 16 below.

| Table 16. Maracallo forest fire environmental damage (standard costs) | | | | |
|--|-----------|---------------------|-------------------------|---------------------------|
| Measure 226 | Area (ha) | Reconstruction cost | Adaptation rate (ISTAT) | Total monetary impact (€) |
| A.1.4.6 | 1.49 | 6 | 1.30 | 18,267.53 |
| | | Discount rate | Years | |
| Forest regeneration cost | 18,267 | 0.02 | 20 | 27,143.72 |

Source: authors' elaboration from Italian Forest Corp data

Sometimes even a fire of modest size with limited environmental damage can result in significant costs associated with the partial or total destruction of tangible assets (civil infrastructures, settlements, agricultural crops, etc.). However, in the forest fire area, no damage to infrastructure, buildings, people or vehicles occurred.

The table 17 below shows a summary of the monetary estimated impact for the Maracallo forest fire that occurred on April 21st, 2010:

| Table 17. Summary of the monetary impacts | |
|--|--------------------|
| Costs for fire suppression | € 21,307.98 |
| Environmental damage (services and goods) | € 27,143.72 |
| Extraordinary external damage (cost for forest regeneration) | € 0.00 |
| Total monetary impact | € 48,451.71 |

4.3 The case of the Rocca Romana (Trevignano) forest fire

Finally, we present a further analytical approach based on the economic assessment of forest fire damage relating to the loss or reduction of the different utility functions (i.e. economic, social and environmental) provided by a forest area. To this end, we take into consideration the forest fire crime that occurred in Rocca Romana, municipality of Trevignano Romano (RM) from August 7th to 10th 2003. Table 18 shows the main information that characterized the fire:

| Table 18. Rocca Romana (Trevignano) forest fire | |
|--|-----------------------------|
| <i>Region</i> | Lazio |
| <i>Province</i> | Rome |
| <i>Municipality</i> | Trevignano Romano |
| <i>AIBFN</i> | N°2/2003/1245 |
| <i>Affected Area</i> | 22 ha |
| <i>Fire cause</i> | Negligence |
| <i>Type of affected forest</i> | Oaks, chestnuts, hornbeams |
| <i>Beginning of fire</i> | 7 th August 2003 |

| | |
|----------------------------------|--|
| <i>End of fire</i> | 10 th August 2003 |
| <i>Utilized vehicles</i> | 2 Canadair CL-415, 1 Helicopter AIB412 |
| <i>Material damages</i> | None |
| <i>Injured and / or deceased</i> | None |

Source: authors' elaboration from Italian Forest Corp data

4.3.1 Estimation method

In contrast to previous forest fires, given the large size of the event and the heterogeneity of the affected area, we considered it appropriate to employ the estimate of the different forest functions for the calculation of the TEV. This approach proposed by Ciancio et al. represents the most accurate and articulate method for the evaluation of the monetary impact of forest fire. In particular, the environmental damage rests on the appraisal of seven forest functions: (i) *wood production loss*; (ii) *non-wood production loss*; (iii) *tourism-recreation loss*; (iv) *hunting activity loss*; (v) *soil protection*; (vi) *protection from climate change*; and (vii) *biodiversity protection*.

The total value of environmental damage results from the sum of the aforementioned seven functions. However, the identification of the seven components of the damage does not imply their contextual involvement in each forest fire event. It is, in fact, unusual that a wildfire produces, for example, both significant damages to the hunting activities of the forest and biodiversity. It is worth noting that, in this case, the hunting function has to be ignored since the Italian law forbids hunting activities in protected areas. Therefore, appraisal of the environmental damage, in this specific case, will take into account the following forest functions: i) the wood production, ii) the non-wood production (in this case it refers to, among others, the collecting of mushrooms), iii) the tourism-recreation and iv) the protection from climate change.

For the estimation of *wood production (WP)*, we recognize that:

$$WP = \frac{M}{n} * Pz$$

where M is the average forest mass per hectare; n represents the average age of the forest and Pz the average price of stumpage.

The average forest mass per hectare (M) was estimated by the weighted average (i.e. number and size of trees) of the data obtained for each hectare of the affected area and by linking them with the 'volume tables' developed by the Italian Forest Corp for forests comparable to that of the

Rocca Romana. The average forest mass is about 230 m³/ha. The average annual increase, given by M/n (where n, average age of the population, is equal to 35 years), is 6.6 m³/ha.

Pz, which is the basic element of the whole economy of forestry production, represents the unit value of the mass in the raw state. It is obtained by subtracting from the end product market value, the necessary processing costs for the management of the raw material (i.e. cutting costs, transportation cost, cost of extraction, cost of insurance and so on). It was calculated by applying data derived from previous experiences in similar conditions and geographical location. Table 19 below shows in detail the different costs of stumpage:

| Table 19. Different costs of stumpage for Rocca Romana forest fire | | | |
|---|-------|----------|-------------------------------|
| Operation | Hours | Cost (€) | Unit cost (€/m ³) |
| Cutting | | | |
| – Specialized worker | 1 | 13,00 | 13,00 |
| – Chainsaw | 0.66 | 4.00 | 2.64 |
| Collection and transport | | | |
| – Tractor | 0.33 | 17.00 | 5.61 |
| – Specialized worker | 0.8 | 13.00 | 10.40 |
| Indirect Costs | | | 12.66 |
| Total cost of transformation | | | € 44.31 |

Source: authors' elaboration from Italian Forest Corp data

The price of stumpage, equal to the difference between the market value of the product and the cost of processing, is € 15.69/m³ (€ 60.00/m³ - € 44.31/m³).

Therefore, the *wood production* (WP) amounts to:

$$WP = \frac{230}{35} * 15.69 = \text{€ } 103.10$$

For the estimation of **non-wood production (NWP)**, it is interesting to verify the existence of *ad hoc* data on NWP (i.e. chestnuts, mushrooms, truffles, acorns) identified by ISTAT for the investigated area. Looking at mushrooms, it is estimated that the yearly average produced quantity is 25 kg per hectare, divided into 15 kg of mushrooms of the genus *Boletus* and 10 kg of the genus *Cantarellus*, *Russula*, *Lattarius*. The local average market price of the *Boletus* mushrooms sits at 14 €/kg and the value attributable to mushrooms belonging to other genres, which have no local market, equals 3 €/kg, the annual value of the benefit produced by mushrooms, in the forest under evaluation, is € 240 per hectare.

Another possible economic aspect of forests is tourism. The economic growth in the past 30 years and the increase in leisure time, combined with the degradation of the urban areas, have resulted in an increase in visits within the protected areas. The tourism function of forests is typically offered through walks, picnics, guided tours, and educational trips for school groups. The monetary appraisal of the recreational value of forests (tourism-recreation function) that generates positive effect on the economy of the local population (which here, however, we do not consider) is carried out using a plurality of methodologies: the cost of an individual trip, contingent valuation and the willingness to pay for a visit. The approach we consider in our study refers to the willingness to pay for a visit in the affected area and can be summarized by the following equation:

$$TR = \frac{v * dp}{Sup}$$

where v is the recorded number of trips per year in the area under evaluation and dp represents the estimate of willingness to pay per visit;

Data from the Touristic Information Point of the Trevignano municipality recorded 4,570 visitors in the whole forest area (200 ha). With regard to the value of willingness to pay for a visit in the forest, a sample survey has been carried out. The interviews show that, on average, a person is willing to pay about 4 € for a day in Rocca Romana forest, which would be the cost of a hypothetical entrance fee. Therefore, the tourism recreation function amounts to:

$$TR = \frac{4570 * 4}{200} = \text{€ } 91$$

One of the most important functions of a forest is carbon sequestration. Over the past decades, forests have moderated climate change by absorbing most of the carbon released by human activities such as the burning of fossil fuels and the changing of land uses. Carbon uptake by forests reduces the rate at which carbon accumulates in the atmosphere and thus reduces the rate at which climate change occurs. The *protection from climate change* function (PCC) is estimated by looking at the economic value of the carbon immobilized by the forest ecosystems. This estimation is very complex and involves several methodological approaches. Our case study relies on the assumption that a forest represents a natural storage for the emissions of carbon. Therefore, we introduce the concept of *carbon tax* for a forest as the "shadow price" of its associated absorption benefit. This seems quite reasonable since, if we assume that the emission of carbon dioxide could be taxed, then the activities that have an opposite effect represent a social benefit. Hence, the PCC function is given by:

$$PCC = \frac{M}{n} * Xn * Xc * C$$

where M is the average forest mass per hectare, n represents the average age of the forest, Xn is the ratio Total biomass/above ground biomass (equal to 1.8), Xc is the biomass conversion factor m³/t carbon (equal to 0.65) and C is the economic value of 1 ton of carbon based on the carbon tax estimation (average carbon tax 10 €/t). The PCC function is equal to:

$$PCC = \frac{60}{35} * 1.8 * 0.65 * 10 = \text{€ } 22$$

Since the fire caused different degrees of damage in two different areas we decided to weight the considered forest functions with the level of destruction of the forest. In particular, data shows that 2 hectares were totally destroyed while 20 hectares were partially touched giving rise to a loss of about 25% of the biomass. Therefore, monetization of the environmental damage for each single forest function is:

- For WP function on 2 hectares: € 103 * 1 = € 103
- For WP function on 20 hectares: € 103 * 0.25 = € 25.75
- For NWP on 22 acres: € 245 * 1 = € 245
- For TR function of 22 hectares: € 91 * 1 = € 91
- For PCC on 2 hectares: € 22 * 1 = € 22
- For PCC on 20 hectares: € 22 * 0.25 = € 5

The total amount of environmental damage is equal to: [(103/0.03)* 2 +(25.75/0.03)* 20 + (240/0.03)* 22 + (91/0.03) * 22 + (22/0.03) * 2 + (5.5/0.03) * 20] = **€ 113.633**

Moreover, fire extinction costs can be quantified by knowing the average personnel cost per hour, the number of people employed, the duration of the extinction operations, and the cost of the equipment used. Clearly, in the case of intervention by voluntary fire fighters, they should not be incorporated into the calculation of personnel costs, but must be included in the quantification of the cost of equipment. Specifically, one helicopter AIB412 and two Canadair CL-415 were used in the fire fighting activities in the Rocca Romana forest fire. Table 20 below shows in detail the equipment used and the related amount of time and money.

| Table 20. Rocca Romana forest fire extinction costs | | | | |
|--|---------------|--------------|------------------------|----------------------------------|
| Equipment and fire-fighters | Number | Hours | Hourly cost (€) | Total monetary impact (€) |
| Canadair | 2 | 8 | 9,000 | 72,000 |

| | | | | |
|-------------------|---|----|------|-----------------|
| Helicopters | 1 | 2 | 5000 | 10,000 |
| CFS Fire fighters | 7 | 12 | 80 | 6,720 |
| TOTAL | | | | € 88,720 |

Source: authors' elaboration from Italian Forest Corp data

Taking into account the duration of the extinction operations, the cost of the equipment used and fire-fighters employed, the total cost of the intervention is **€ 88,720**.

Table 21 below shows a summary of the monetary estimated impact for the Rocca Romana forest fire that occurred from August 7th to 10th, 2003:

| | |
|--|------------------|
| Environmental damage (forest functions) | € 113,633 |
| Costs for fire suppression | € 88,720 |
| Extraordinary external damage (cost for forest regeneration) | € 0.00 |
| Total monetary impact | € 202,353 |

Source: authors' elaboration from Italian Forest Corp data

5 Conclusion

5.1 Summary of the extent of the impacts

This report summarizes the current status of wildfire impacts, in both quantitative and monetary terms and, to some extent, whether the geographical impact of fire crimes is correlated to the presence of organized crime across Italian regions. It could represent the beginning of a dialogue on what data and knowledge are still needed to inform policy makers in order to better prevent and reduce negative economic, social and environmental impacts of forest fire crimes.

Due to data limitations, the analysis was carried out at two different geographical levels (European and Italian) and took into account different time spans. In particular, the European level analysis focused only on the environmental impact of fire crime while the regional level analysis (Italy) took into account the assessment of other impacts arising from fire crime

(health, material and monetary) and the possible correlation between organized crime and fire crimes.

During the last decade, in the 21 Member States, forest fires due to human causes burned a total area of 1,535,572.41 ha. The magnitude of such devastation is particularly significant for the southern Member States. Spain was the most affected country in terms of burnt area with 55% of the whole burnt area in Europe (848,241.4 ha), followed by Italy (558,643.4 ha) and Portugal (72,838.3 ha). Conversely, less affected countries were Finland (14 ha), Belgium (52.7 ha) and Slovakia (98.5 ha). Given the lack of suitable information at a wider geographical level, the event-specific nature and the broad heterogeneity of this type of crime (i.e., protected areas, national parks, wooded/non-wooded area, etc.) the health, material and monetary impact of fire crimes were measured only at the Italian level. Data from NIAB reporting system show that over the decade 2003-2012, the number of human casualties due to forest fires in Italy amounted to 55, while 442 people suffered an injury. The most dramatic season was recorded in 2007 with 23 deaths and 26 injured. Moreover, although the number of fire crimes that occurred in the country in 2012 decreased (5,246) with respect to 2011 (5,296), the total number of fire events that caused material impacts on *vehicles, chattels personal, real estate* and *farm animals* significantly increased from 273 to 385 fires.

The article 423-bis Italian Penal Code introduced by Law 353/2000 has introduced more effective legal instruments for carrying out the investigations and analyzes the phenomenon of forest fire crime in depth. In this context, the actions against forest fire offences undertaken by the territorial Italian Forest Corp in 2012, made it possible to report 614 people to the judicial authority, of which 563 were charged with negligent fires and 51 for arson. Although, from a more in depth analysis, evidence has emerged of a positive correlation between organized crime (i.e., mafia-like organizations) and the number of fire crimes, looking at the judgments issued by the judicial authority, mafia-like organizations have a very marginal role in forest fire crimes. Organized criminals responsible for deliberate fires represent, actually, only isolated and sporadic actions.

The monetization of damages resulting from wildfires has been the subject of extensive analysis by various authors from the monitoring and reconstitutions aspects as well as the environmental and social impacts. In this respect, following the methodologies proposed by Ciancio et al. (2007), we focused on three different forest fire crimes that occurred in Italy, (Morfasso (VA) 22nd - 23rd July, 2010, Maracallo (PC) 22nd April, 2011, and Trevignano (RM) from 7th - 10th August, 2003) employing three distinct approaches (analytical, standard costs and forest utility approach) to determine the three components of the damage (i.e. *extinction*

cost, environmental damage, external damage) owing to the heterogeneity of the investigated fire crimes.

5.2 Research needs and recommendations

The analysis of the impact of fire crimes in both quantitative and monetary terms presents several difficulties which relate to both methodological and data availability issues. From the methodological point of view, the impact assessment of forest fire crime has to take into consideration the fact that each fire produces several impacts (environmental, health, economic and social) that are very specific to the particular area where it occurs. Moreover, it is worth noting that fires directly impact benefits and resources that people receive from the environment, but only a minor part of them exhibit a market price that can be used as a possible proxy for assessing their value, while the majority of goods and services is not marketed. However, although EFFIS represents a useful and effective effort to collect data in a harmonized way among the Member States, it lacks adequate indicators to measure the economic, social and health impacts of forest fire, making results incomparable among different countries.

Our conclusions on data availability and methodological issues raise two important questions. First, would more harmonized data on wildfire impacts be a valuable tool for policy makers, and hence worth the costs of data collection? And, if so, how could we effectively carry out data collection, which information do we really need, and how can this knowledge be exploited to provide policies and practices to prevent and reduce negative economic, social and environmental impacts of wildfires?

Given the broad heterogeneity of forest fire impacts, the long time horizon for ecosystem recovery, and due to the trans-boundary nature of the events, the policy planning for their prevention should be seen from a regional perspective in order to discuss preventive measures, improve the international cooperation and identify opportunities for further collaboration among European Member States. This report highlights the availability of information that characterizes different forest fire impacts, but it does not consider the role of policy over time, for instance fire prevention or other management decisions that could affect the likelihood of forest fire and the extent of different impacts. Therefore, our findings may open the way for further investigations on the cost, effectiveness, and impacts of preventive management actions on forest fire crime, and contribute towards determining best practices in forest fire management.

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Annex A

Table 3: Assessing the environmental impact of forest fires in the 21 Member States from 2003 to 2012.

| Nuts Code | Country | Number of fires 2003 - 2012 | Burnt area 2003-2012 (ha) | Average burnt area per fire (ha) | Unknown causes | Known causes | Deliberate total | Crime % Deliberate/Known | Known causes % | Environmental Impact (ha) |
|--------------|------------|-----------------------------|---------------------------|----------------------------------|----------------|--------------|------------------|--------------------------|----------------|---------------------------|
| BG | Belgium | 4,742 | 925 | 0.19 | 1,527 | 3,215 | 270 | 8.3 | 67.8 | 52.7 |
| CH | Switzer. | 679 | 870 | 1.28 | 325 | 354 | 154 | 47.3 | 52.2 | 197.3 |
| CZ | Czech Rep. | 3,586 | 1,050 | 0.29 | 962 | 2,624 | 559 | 21.3 | 73.1 | 163.7 |
| CY | Cyprus | 1,617 | 6,123 | 5.02 | 208 | 1,409 | 280 | 19.8 | 87.2 | 1,198 |
| DE | Germany | 5,637 | 3,057 | 0.54 | 2,819 | 2,818 | 450 | 15.9 | 50.9 | 244 |
| ES | Spain | 163,818 | 1,556,386 | 9.5 | 23,752 | 140,066 | 89,282 | 63.7 | 85.3 | 848,241.4 |
| FI | Finland | 13,340 | 898 | 0.06 | 2,970 | 11,400 | 229 | 2.0 | 79.3 | 14 |
| FR | France | 42,501 | 172,557 | 4.06 | 21,379 | 21,122 | 6,033 | 28.5 | 49.7 | 24,494.4 |
| GR | Greece | 5,672 | 23,222 | 4.09 | 8,523 | 8,357 | 3,819 | 45.6 | 49.8 | 15,619.71 |
| HR | Croatia | 22,630 | 12,349 | 0.54 | 7,043 | 15,587 | 3,160 | 20.2 | 68.8 | 1,724.4 |
| HU | Hungary | 7,222 | 14,322 | 1.98 | 5,438 | 1,784 | 206 | 11.5 | 24.7 | 408.2 |
| IT | Italy | 72,597 | 798,305 | 11.613 | 19,250 | 73,347 | 48,105 | 65.6 | 73.4 | 558,643.4 |
| LT | Lithuania | 3,451 | 945 | 0.27 | 273 | 3,178 | 397 | 12.4 | 92.1 | 108.7 |
| LV | Latvia | 5,665 | 1,232 | 0.22 | 751 | 4,914 | 784 | 15.9 | 86.7 | 170.5 |
| PL | Poland | 6,328 | 29,004 | 4.5 | 4,564 | 1,764 | 1,288 | 57.2 | 84.8 | 5,903.5 |
| PT | Portugal | 245,334 | 999,984 | 3.8 | 188,931 | 56,403 | 17,870 | 31.6 | 22.9 | 72,838.3 |
| RO | Romania | 2,262 | 3,823 | 1.69 | 690 | 1,572 | 478 | 30.4 | 69.4 | 807.9 |
| SE | Serbia | 2,670 | 5,648 | 2.11 | 1,064 | 1,606 | 822 | 33.1 | 59.7 | 1734.4 |
| SI | Slovenia | 919 | 1,487 | 1.61 | 326 | 593 | 135 | 22.7 | 64.5 | 218.4 |
| SK | Slovakia | 2,612 | 875 | 0.33 | 264 | 2,348 | 294 | 12.5 | 89.8 | 98.5 |
| TR | Turkey | 12,731 | 24,246 | 1.90 | 5,809 | 6,922 | 1,413 | 20.4 | 54.3 | 2,691 |
| TOTAL | | | | | | | | | | 1,535,572.41 |

Source: authors' elaborations on EFFIS database

Annex B

Table 4. Number of fire crimes, average burnt area and environmental impact in the five southern Member States over the last decade

| | ITALY | SPAIN | PORTUGAL | FRANCE | GREECE | TOTAL |
|-----------------------------------|-------------------|------------------|------------------|---------------|-----------------|---------------------|
| Number of Fire crimes | | | | | | |
| 2003 | 6,720 | 10,123 | 8,101 | 554 | | 25,818 |
| 2004 | 4,823 | 8,402 | 6,657 | 355 | 290 | 20,527 |
| 2005 | 3,422 | 7,867 | 5,210 | 562 | 231 | 17,292 |
| 2006 | 4,238 | 8,723 | 3,212 | 455 | 180 | 16,808 |
| 2007 | 8,384 | 15,168 | 2,997 | 1,345 | 724 | 28,618 |
| 2008 | 4,250 | 12,123 | 9,990 | 567 | 423 | 27,353 |
| 2009 | 3,251 | 5,423 | 4,234 | 352 | 196 | 13,456 |
| 2010 | 2,475 | 6,702 | 6,455 | 398 | 320 | 16,350 |
| 2011 | 5,296 | 7,093 | 4,478 | 575 | 312 | 17,754 |
| 2012 | 5,246 | 7,656 | 5,069 | 870 | 823 | 19,664 |
| Average | 4,810.5 | 8,928.2 | 5,640.3 | 603.3 | 381.9 | 20,364.2 |
| Total | 48,105 | 89,282 | 56,403 | 6,033 | 3,819 | 203,642 |
| Aver. Burnt Area (ha) | | | | | | |
| 2003 | 13.6 | 7.8 | 2.3 | 3.7 | 3.7 | 6.22 |
| 2004 | 9.4 | 9.4 | 1.8 | 5.1 | 4.8 | 6.1 |
| 2005 | 6.01 | 6.8 | 5.3 | 3.1 | 3.6 | 4.96 |
| 2006 | 7.8 | 9.3 | 3.4 | 2.5 | 2.4 | 5.08 |
| 2007 | 21.4 | 12.4 | 5.5 | 7.1 | 6.8 | 10.64 |
| 2008 | 10.3 | 12.2 | 3.8 | 3.1 | 3.6 | 6.6 |
| 2009 | 13.5 | 5.4 | 3.3 | 5.2 | 5.2 | 6.52 |
| 2010 | 9.52 | 10.8 | 2.3 | 1.8 | 1.6 | 5.2 |
| 2011 | 8.8 | 7.4 | 3.2 | 2.8 | 2.55 | 4.95 |
| 2012 | 15.8 | 13.2 | 6.8 | 6.1 | 67 | 9.72 |
| Average | 11.6 | 9.5 | 3.8 | 4.05 | 4.09 | 6.61 |
| Environmental Impacts (ha) | | | | | | |
| 2003 | 91392 | 78,959.4 | 18,632.3 | 2,049.8 | 1,184 | 192,217.5 |
| 2004 | 45,336.2 | 78,978.8 | 11,982.6 | 1,810.5 | 1,392 | 139,500.1 |
| 2005 | 20,566.22 | 53,495.6 | 27,613 | 1,742.2 | 831.6 | 104,248.62 |
| 2006 | 33,056.4 | 81,123.9 | 10,920 | 1,137.5 | 432 | 126,669.8 |
| 2007 | 179,417.6 | 188,083.2 | 16,483.5 | 9,549.5 | 4,923.2 | 398,457 |
| 2008 | 43,775 | 147,900.6 | 37,962 | 1,757.7 | 1,522.8 | 232,918.1 |
| 2009 | 43,888.5 | 29,284.2 | 13,972.2 | 1,830.4 | 1,019.2 | 89,994.5 |
| 2010 | 23,562 | 72,381.6 | 14,846.5 | 7,16.4 | 512 | 112,018.5 |
| 2011 | 46,604.8 | 52,488.2 | 14,329.6 | 1,610 | 795.6 | 115,828.2 |
| 2012 | 82,886.8 | 101,059.2 | 34,469.2 | 5,307 | 5,514.1 | 229,236.3 |
| Average | 61,058.55 | 88,374.97 | 20,121.09 | 2,751.1 | 1,812.65 | 174,118.36 |
| Total | 610,485.52 | 883,749.7 | 201,210.9 | 27,511 | 18,126.5 | 1,741,083.62 |

Source: authors' elaborations on EFFIS Database

