

Analysis of fatalities originated by burning of agricultural and forestry residues in Portugal

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ABSTRACT:

Forest fires are a major problem that occur in Portugal every year during the summer months and usually get major coverage by the media. The burning of agricultural and forestry residues tend to have less impact in the media but they often result in large fires and fire related accidents. These ancient practices, a part of rural heritage, in some cases result in fatal accidents. This is a growing problem and has not received much attention from the authorities.

This paper describes some of these accidents, chosen from a large set of cases that have been inventoried and studied in the last years by the Centre for Forest Fire Studies of ADAI. An historical analysis is done based on data collected in Portugal for each one of the identified fatal accidents related to these residues burning. We studied in detail four cases that resulted in fatalities, reporting the victims' characterization and the circumstances of the accident.

In the place of each accident the topography, meteorology, vegetation, fire behaviour, the situation of wildland urban interface and the conditions in which the burnings were made are characterized. The victims were characterized according to their profession or current occupation, age and gender.

This paper aims to contribute to a better understanding on these situations and to aid in the mitigation, or prevention of such accidents in order to minimize its occurrence in the future.

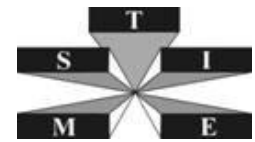
KEYWORDS:

Wildfires, rural fires, burnings, burn victims, risk

1. INTRODUCTION

Wildfires are one of the most devastating natural hazards in Portugal having large impacts on the economy, environment and society [1]. Natural caused wildfires have always been part of the ecosystems of the Mediterranean region and are responsible for significant changes in the landscape [2] however the actual figures of the burnt area currently verified in Portugal have high a percentage of anthropogenic causes.

Portugal has a temperate climate with Mediterranean influence, characterized by hot and dry summers, and rainy winters. The topography in Portugal, especially in the centre and north, is very sloppy and the typical vegetation is adapted to dryness and have pyrofit characteristics. These natural conditions make Portugal very susceptible to wildfires, and this susceptibility has been increasing in recent decades due to natural, demographic and socioeconomic changes [3]. The population in rural areas decreased and the average age has increased as a result of the exodus of young people to the cities. Rural and forest properties are typically small, mostly in the centre and north of Portugal, and are frequently managed by people over 65 year's old. Areas previously dedicated to agriculture were gradually converted to forested areas frequently improperly managed



and other areas were abandoned accumulating natural vegetation and becoming uncultivated areas of scrubland with high fuel loads [4].

Currently, approximately 98% of the fires occurred in Portugal result from anthropogenic factors [5], and only 2% have natural causes [6]. Accidental or negligent use of fire are frequently associated to the common practice of burning slash or other agricultural and forest residues which are burnt in fires aiming its destruction, from now on mentioned as “agroforestry burns”. Additionally, in order to renovate the grazing lands, there is an ancestral practice of making small prescribed fires that frequently get out of control. Several fatalities are known as having been originated by agroforestry burns however only recently this cause was analysed separately from other fatalities related to wildfires and therefore only recently accurate data are available [7]. One of the most exhaustive studies analysing fatalities related to agroforestry burns was carried out by the Association for the Development of Industrial Aerodynamics (ADAI) which collected, investigated and reported the accidents involving fatal events related to wildfires in the years of 2003 [8], 2005 [9] and Rosa [2012]. The present work aims to improve the understanding of the social and cultural aspects related to some of the known fatalities originated by agroforestry burns in Portugal between 1988 and 2015.

This study focused on the accidents that occurred in Continental Portugal where the probability of having such accidents is higher.

2. METHODOLOGY

The survey of the fatalities originated by agroforestry burns that occurred in Portugal was carried out by a review of the news reported on the internet, national and local radio stations, newspapers and TVs, and by a review of the existing literature on this them from which we highlight the books referenced as [8] and [9]. In the scope of this survey several Portuguese civil protection and rescue services, as well as criminal investigation and law enforcement authorities were invited to give information related to three issues: 1) the number of fires which have killed people since 1988, referencing the place, the date, the circumstances and the number of victims; 2) the number of fires held annually since 1980; and 3) the number of agroforestry burns that escaped to control triggering a wildfire event.

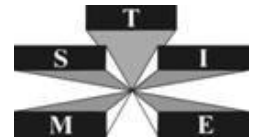
The gathering and compilation of the data allowed an analysis aiming at the spatial characterization of the occurrences that was performed using the ArcGIS 10.2 software.

Finally, some of the most impactful events were selected for a more detailed analysis addressing the following issues: type of vegetation, fire behaviour, topography, weather, characterization of wildland-urban interface (WUI) area, characterization of the victims and circumstances in which these accidents occurred. Interviews to firefighters involved in the events, to the victims' relatives and to the neighbours of the victims were conducted. People involved in the accidents such as family or friends or who had hastened to the local immediately after the accident were invited to describe the scenario and the situation lived. All the data, evidences and witness testimonials were compiled and analysed in order to have the accidents descriptions as accurate and complete as possible.

3. RESULTS AND DISCUSSION

The CEIF team investigated in the last 30 years most of the fatal accidents related to forest fires in Portugal and in some other countries. Inseparable from these accidents are the cases of deadly victims caused by burning of agricultural and forestry residue also related to forest fire management. The data collected on these cases are presented in two books entitled *Cercados pelo Fogo Vol. I and II*. In these books a very precise description of the facts, environment and victims was made.

The collection of data on cases of fatalities in agricultural and forestry residues was done through several stages. As it is not common practice that a single agency collects this type of data a general enquiry to several governmental authorities was made but it did not get many responses. Then a more direct approach to other



sources like local Fire Brigades, CEIF team, students, National Republican Guard (GNR), National Authority of Civil Protection agents, national and regional newspapers, radios and television was made.

The Mainland of Portugal have a total of 445 Fire Brigades who were contacted by mail, email, or phone to answer a small questioner with 3 questions. Only 33 of them answer the questioner (7.4%) of the Fire Brigades. Nature and Environmental Protection Service of the GNR report 8 deadly cases from 2008 to 2011. This department was created in 2007 and for the motive the cases previously 2008 aren't report by this service. Despite the cases reported by this service the data wasn't completed and in the most part of this recorded the gender or the age of the victim's wasn't completed. The national and regional televisions, radios and newspapers reported eight more deadly victims in the years of 2011 and 2012, 2014 and in the first trimester of 2015.

3.1. Distribution of accidents

The several information sources consulted reported 39 fatal cases originated by agroforestry burns since 1988 to March 2015. 31 of the 39 cases surveyed occurred after 2005. As previously mentioned, in 2005, the accidents originated by agroforestry burns started to be classified separately and therefore the information about accidents occurred before this year may not have been found.

In figure 1 the geographic dispersion of the fatal accidents occurred in Portugal between 1988 and March 2015 is presented. It is possible to verify the larger concentration of cases occurred in the North and Centre of Portugal compared with the south regions.



Figure 1 – Spatial distribution of the victims of rural burns in Portugal from 1988 to 2015.



In figure 2 it is possible to see that Coimbra, Leiria, Vila Real and Viseu are the districts with more fatalities originated by agroforestry burns. However all districts with the exception of Bragança, Évora and Beja have at least one fatal accident reported in the period mentioned before (1988-2015).

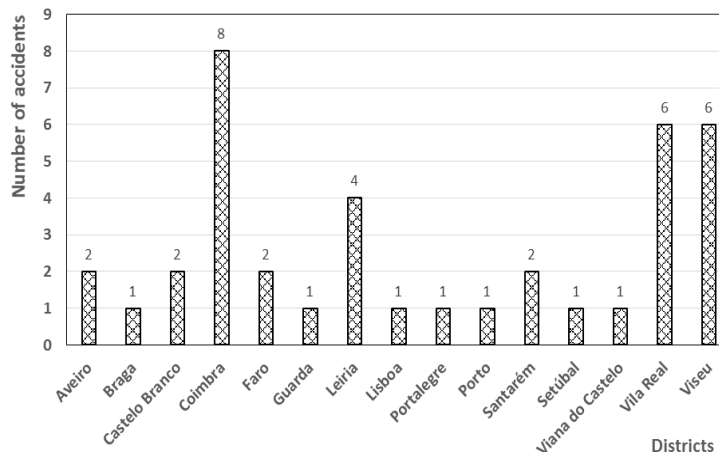


Figure 2 - Distribution of the victims for district in the period from 1988 to 2015.

The first case reported in this study occurred in 1988. During 14 years period we did not have any reported case of burn victims linked to rural fires or burning of agricultural or forestry residues. In the period between 2005 and 2014, the most dramatic years are those of 2005, 2007, 2010 and 2012 when the larger number of cases were reported (figure 3). In the first trimester of 2015 two fatal accidents originated by agroforestry burns have already occurred in the month of March. The average of deadly victims by year is 3.0 but this value was duplicated in 2010 and 2012.

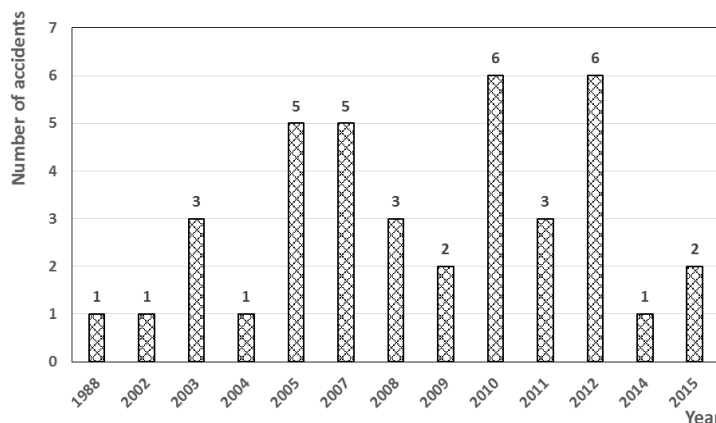
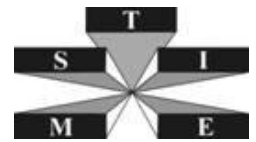


Figure 3 - Distribution of victims by year

The months that reported more deadly victims are March and October with 7 case each (figure 4). In Portugal usually the higher temperature and lower relative humidity values are registered in July, August and September and the number of victims is lower than in the other periods of the year because people tend to make less burns in the summer period. Contrarily to what could be expected, this type of accidents frequently occur during the first trimester of the year which is coincident to the later winter season in Portugal. The existence of a period when the burning is not allowed (from May 15th to September 15th) and a period when the burning is allowed (rest of the year) may cause the wrong sensation that making agroforestry burns out of the critical period has reduced risks and that people can use the fire without the convenient safety procedures.

Most part of these people did not realize how the conditions changed in the last decades. For one side the



physical shape is not the same as some years ago but we can see that some burns are made in a way that requires a great physical capability. On the other side, with the rural exodus and the accumulation of fuels in uncultivated areas that have been noticed in Portugal in the last decades, the probability of a burning haywire to a uncontrolled fire increased dramatically.

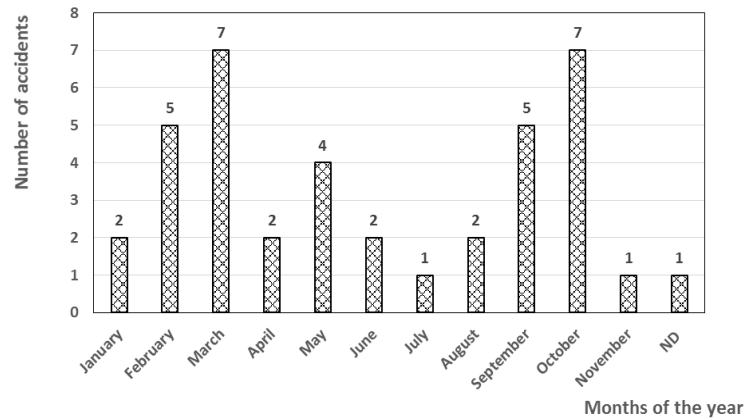


Figure 4 - Distribution of the victims by months

The distribution of victims by gender and age is shown in figure 5 where it is possible to see that males with 75 to 80 years old is the most representative class among the groups of victims. The average age of the victims was 75.0. As previously mentioned, the population in rural areas is aging and the subsistence farming is mostly developed by elder people who naturally have lower endurance to manage a fire or to escape from a dangerous situation. On the other side culturally in Portugal agroforestry burns are commonly handled by men with a percentage of 61.53% of the fatal cases reported.

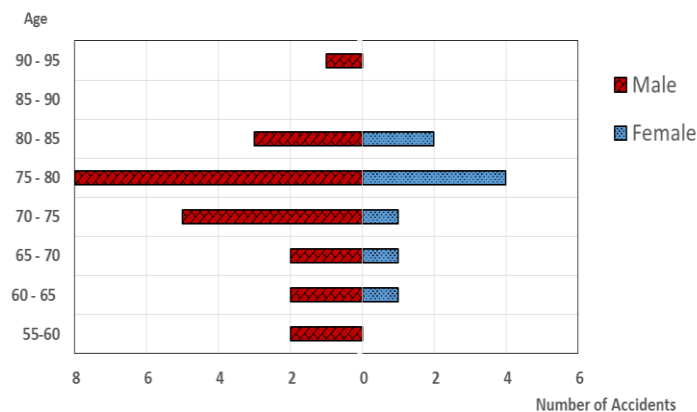


Figure 5 - Distribution by gender

Most part of the fatal cases are registered outside the critical period of wildfires (figure 6) 74.35% of the reported cases against the 25.64% during the critical period. In Portugal this period is usually in late spring and summer and is defined by law to be from the 15 of May to 15 of September (Law number 17/2009 of 14 of January).

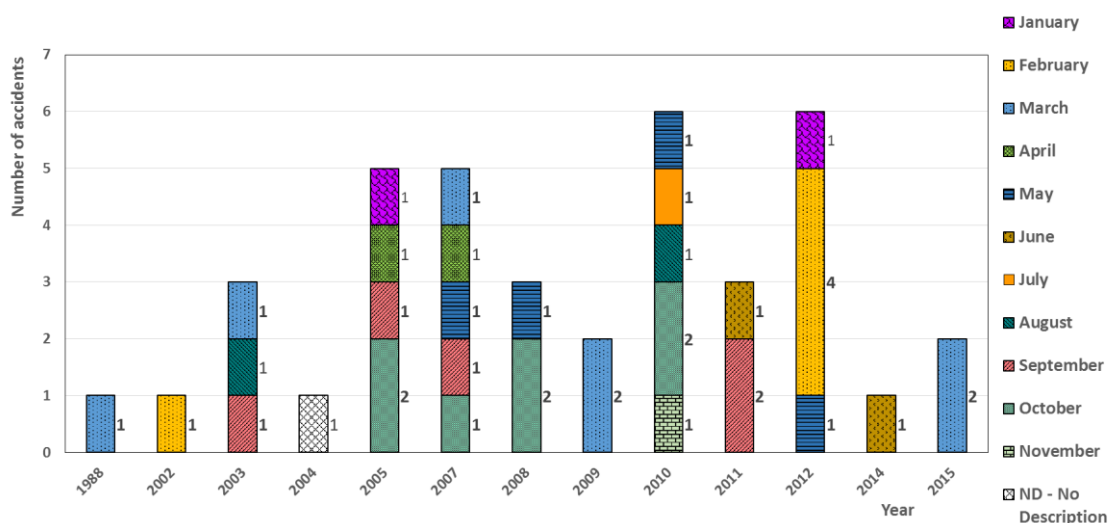
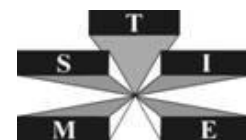


Figure 6 - Distribution of the number of victims by year and month.

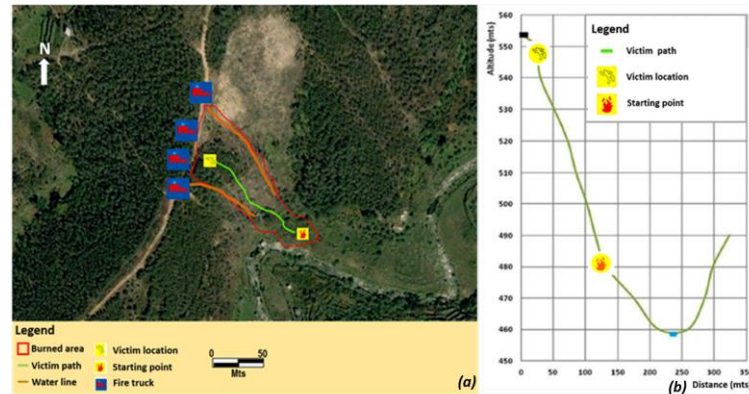
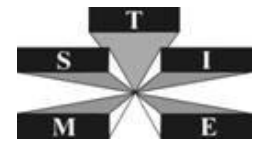
3.2. Description and analysis of some case studies

Among the 39 cases reported involving deaths originated by agroforestry burns, we choose four cases to make a more detailed analysis. The main motivation to choose these cases was the difference in the patterns between them. The first case that occurred in the Vasco Esteves de Baixo shows an unusual strength of a 78 years old man who climbed a very steep slope with the intention to extinguish the fire he started. The second case occurred in Loureiro de Silgueiros and involved a 77 years old man with a recurrent record in more than 25 years of being advised by the authorities for putting fires. The third case occurred in Cabaços and the victim was an 82 years old woman in a terrain she had near to her house, this accident occurred in an area of WUI. The last case we chose occurred in São Martinho do Bispo. The victim was a 78 years old woman who died in her back yard without any contact with the flames.

3.2.1. Case study of Vasco Esteves de Baixo

On February 20th of 2002 in Vasco Esteves de Baixo, Alvoco da Serra, municipality of Seia, district of Guarda occurred a wildfire as consequence of an agroforestry burn that caused the death of a 78 years old man. The victim was retired and owner of the terrain. In this day his wife was with him working in the field. The landscape in the mountain is characterized by steep slopes and the cultivated parcels are very small and all the pieces of flat terrain are occupied with agriculture. It is typical in such cases that the person who starts the fire tries to extinguish it by any means to avoid problems with his neighbours.

The Fire Brigade of Loriga received an alert of a wildfire in Maceiras and immediately moved to the scene 4 operational vehicles. The fighting started in the head of the fire near to the ridge (figure 7 a) in contradiction of the protocol as at this point the fuel was lower and the intensity of fire was also lower. The fire was extinguished from the head to the bottom of the valley by the flanks, when the brigade arrived at the bottom they saw one elderly woman crying and saying that her husband had climbed the slope alone to extinguish the fire with an hand tool.



Then the Brigade climbed once again the slope and found an elderly men dead 5 meters from the road near the ridge. The elderly had severe burns in the face, thorax and arms.

To analyse the slope of the area and the difficulty of progression of victim, we built up a topographic profile shown in figure 7b. In this way we can see that the slope of the path taken by the victim was around 36° (approximately 73%) which allows us to draw some conclusions regarding the mobility of the septuagenarian and the fire behaviour in such situations.

This accident occurred according to the military map n° 234 in an altitude it varies between 470 and 560m and in a South exposure, receiving greater radiation causing a lower moisture content of the fuel. In this case we had an eruptive fire behaviour phenomenon that is responsible for numerous accidents both in Portugal and abroad.

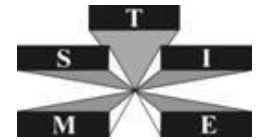
In this day the meteorological parameters for the district of Guarda was 4.1°C of temperature, 39.9% of relative humidity and the wind speed was 17.5 km/h with gusts of 50.4 km/h. There was no precipitation during the 12 days prior to the accident. The Drought Code Index (DC) in the day was 92.73 that is considered as moderate. The fuel cover on the accident site was a maritime pine stands aged between 15 and 20 years and shrubs with about 1.5 m in height (figure 8).



Figure 8 - Fuel cover in the area where the accident occurred

3.2.2. Case study of Loureiro de Silgueiros

On September 14th of 2012 in Loureiro de Silgueiros, municipality and district of Viseu, a rural fire as consequence of an agroforestry burn that caused the death of a 77 years old man occurred. The victim was retired and owner of the terrain. In this day he decided to burn residues of agriculture alone around the 3:00pm. The



Volunteer Fire Brigade of Viseu received an alert to a wildfire in Loureiro de Silgueiros around 3:45pm and immediately moved to the scene one operational vehicle with 5 elements (figure 9).

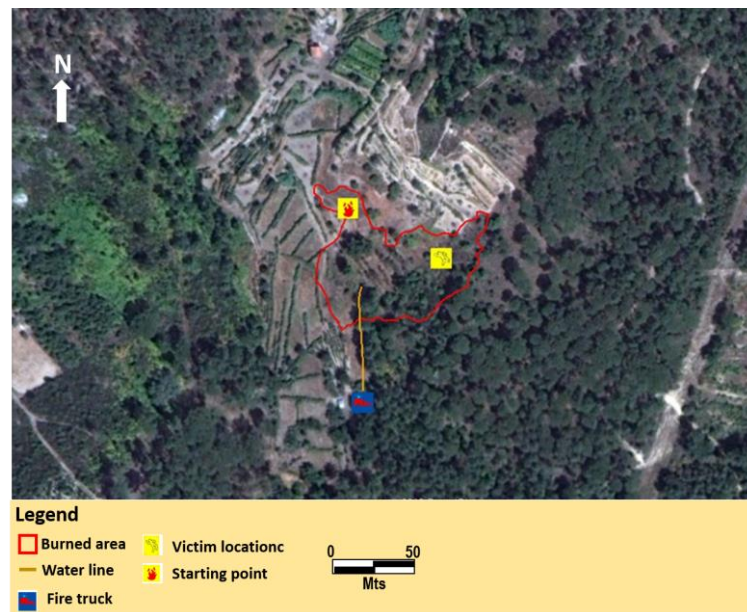


Figure 9 - Description of Loureiro de Silgueiros events

The helicopter and the air team from the National Guard (GNR) were already fighting at the scene. During the operations teams from Volunteers Fire Brigade of Nelas, Cabanas de Viriato and Viseu Municipal arrived.

The vehicle of the volunteers of Viseu started the fighting by the right flank with a water line of proximally 125m of hose. The elderly started burned small portions of grass and controlled them with a hand tool. According a neighbour the septuagenarian had problems a few years before with this type of practices and he was referenced by the authorities. During the process the septuagenarian let the fire to outbreak and go to a small stand of juvenile *Eucalyptus globulus Labill* nearby.

At the end of fighting operations the Fires Brigades at the scene returned to the vehicles and prepared to leave the site. It is usual when the burned areas are small that the leaders of the operations make an inspection by foot with other element, to check if the fire is completely extinguished. In this inspection, the team leader of the volunteers of Viseu found a body with the legs and the feet burned (figure 10 a). Immediately the authorities were called to the local to identify the victim and initiate the procedures to remove the body to the medical coroner (figure 10 b).



Figure 10 - a) Detail of the location of the victim (b) Municipal Fire Viseu await the arrival of the health delegate to certify the death. (Source: (a) CEIF / ADAI, (b) Correio da Manhã edition 15-Sep-2011)

This accident occurred according to the military map nº 199 in a flat slope with small differences of altitude and with a South exposure, receiving greater radiation as well. In this day the meteorological parameters for the district of Viseu was 33°C of temperature, 50% of relative humidity and 15.2 km/h wind speed with gusts of 54 km/h. The prior 13 days before the accident don't register any rainfall the last record of rainfall was in September first with 21.4mm in that day. The September of 2011 was a month extremely dry. The DC in the day was 343.02 that is considered as extremely high.

The fuels are initially herbaceous (figure 11 a) and after the outbreak are a mix of juvenile *Eucalyptus globulus* Labill and some *Quercus suber* (figure 11 b).

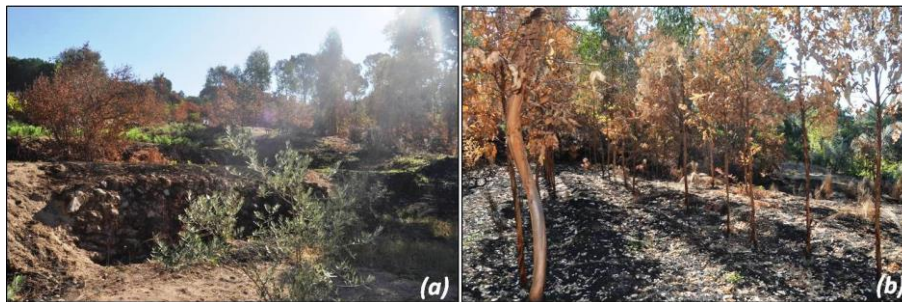


Figure 11 - Fuel cover in the area where the accident occurred

3.2.3. Case study of Cabaços

On February 22th of 2012 in Cabaços, municipality of Moimenta da Beira, district of Viseu a rural fire as consequence of a burn of *Quercus suber* L leaves occurred causing the death of an 82 years old woman. The victim was retired and owner of the terrain where it happened. The victim who had mobility difficulties because she had a prosthesis in a leg decided, against the will of her daughter to go alone to collect the leaves of *Quercus* near her house (figure 12 a) with the intention to burn them (figure 12 b).

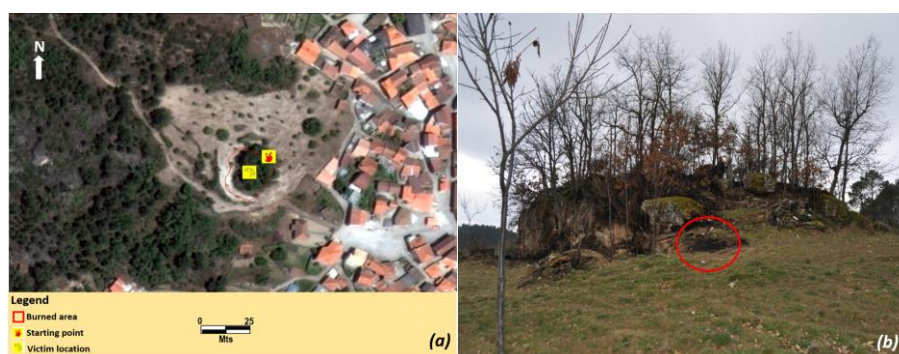
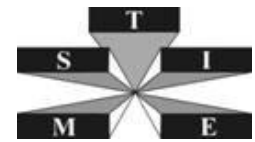


Figure 12 – (a) Detail of the area of Cabaços accident (b) view of the starting point area

At 12h30pm, her son in law called the Moimenta da Beira Fire Brigade to report an accident with her mother in law, and asked for a fire truck and an ambulance to Cabaços. The area where the accident occurred is characterized by a typical WUI layout in the border of urban constructions surrounded by agriculture parcels. The burned area had approximately 800 m² and was located near a wall of stones with few *Quercus suber* L on its top (figure 12 b). According to the victim's son-in law the elderly woman had gone early in the morning alone to the propriety to collect the leaves started a fire and lost the control of the flames that progressed to the upper part of the ground.

When the firefighters arrived they found the victim sitting back in a small step on top of the stones with the



body charred. When the CEIF team visited the place on March 17th of 2012, few days after, the tools (figure 13 a) used by the elderly woman as well as some pieces of burned clothing (figure 13 b) were still visible.

The body of the elderly woman was transported to the Coroner Officer at São Teotónio Hospital in Viseu. Her daughter also resident in Cabaços had warned her mother on several occasions of the danger of fires in this time of the year, especially without rainfall.



Figure 13 - (a) Tool used by the elderly woman (b) pieces of burned clothing

This accident occurred according to the military map n° 148 in a flat slope with a South (S) exposure. In this day the meteorological parameters registered at Vila Real Meteorological Station was 13.3°C of temperature, (the lower temperature since 1932 registered in Vila Real Meteorological Station), 49% relative humidity and 2.9 km/h wind speed blowing from the West (W) quadrant. The February of 2012 was an extremely dry month, the DC in the day was 93.51 that is considered as moderate. The fuel dryness state, exposure, shape and slope will have contributed to a rapid spread of the fire after the outbreak and to change their behaviour.

3.2.4. Case study of São Martinho do Bispo

The last case study, occurred on June 28th of 2014 in São Martinho do Bispo, municipality and district of Coimbra and caused the death of a 71 years old woman. The victim was retired and owner of the terrain where it happened. The victim who had mobility difficulties because she had been surgically intervened to the heart.

At 5h07pm the District Command active for a rural fire in São Martinho do Bispo (figure 14 a) three crews and three operational vehicle's. The vehicle of the Volunteers Fire Brigade of Coimbra takes about 9 minutes from the headquarters to the scene. Upon arrival at the scene the leader performs a visual recognition and informs the District Command the human and material means present in the local was sufficient and assumed the command of operations, until the arrival of the senior element of Municipality Fire Brigade. When the crew of the volunteers Fire Brigade of Coimbra arrived, only a very small portion of grass burn with a grey smoke, nothing serious for the Portuguese Fire Brigades used to large fires.

Immediately the small fires were extinguished. As usual, if the burned areas are small the leaders of the operations make an inspection by foot with other element, in this case a female element of the Volunteers Fire Brigade of Coimbra found a body face down without any burnings (figure 14 b) behind a small elevation of land.

The crew of the Volunteers of Coimbra starts immediately the *Basic Life Support* protocol while the leader request to the local differentiated medical support. The differentiated medical support arrived very fast with a medicalized ambulance and a special vehicle of emergency with a doctor on-board. After the manoeuvres of resuscitation the medic at the local confirm the death of the elderly on site. The body of the elderly woman stay at the local until the National Police arrived to the local and initiated the protocol to remove the body from the place to the coroner located in the Medicine Legal in Coimbra.

According to her daughter the victim had been surgically intervened to the heart 15 days before the accident. The victim had been seen by neighbours in the morning to gather mounds of agricultural residues apparently to burn. During this bonfires cleaning actions results shorts spot fires projections (2-5 m) which started the fire in the lands of neighbours. The place where the victim die as shown in figure 13 is a yard,

perfectly bonded by the urban area.



Figure 14 – (a) Detail of the area of the location of the victim (b) Detail of position of the victim

This accident occurred according to the military map n° 241 in a flat slope with a northwest (NW) exposure. In this day the meteorological parameters for the district of Coimbra was 18.2°C of temperature, 45% of relative humidity, 12.3.2 km/h wind speed and 10mm of rainfall. The DC in the day was 179.38 that is considered high.

The fuels are very high herbaceous with 1.5 to 2 m in average (figure 15) nearby her home.



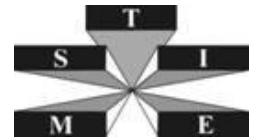
Figure 15 – Fuel complex existing in the area of accident of São Martinho do Bispo

4. CONCLUSIONS

Wildfires that are one of the most devastating hazards in Portugal are quite often originated by negligent practices associated to the use of fire, namely improper management of burning of agricultural and forestry residues. Since during the months from May to September that are considered as critical period of wildfires agroforestry burns are not allowed most fatalities occur out of this period.

The average age of the victims is around 75 years and correspond mostly to individuals of male gender who usually make more agroforestry burns. As mentioned before the agriculture of subsistence is mainly developed by elder people that always have been handling fire in agroforestry burns.

Most fatal accidents analysed occurred in the North and centre of Portugal, which coincides with the regions where the probability of wildfire is statistically higher due to the combination of high values of vegetation load, rough topography and periods of high temperature and low relative humidity. Frequently the accidents occurred during days with high values of fire risk indexes like DC when the burns should be avoided. The typical elder people involved in the accidents to not have access to this information that is commonly



available on the internet with which they are not able to deal. This information is available in physical supports during the fire critical season when the burns are not allowed. We suggest the prohibition of burnings during the days with higher fire risk and the availability of this information in accessible spots or by other means like telephone numbers dedicated to give information. Moreover an extra-effort of education on the topic of wildfires should be provided to this group of people.

As a recommendation to mitigate the fire risk, the landowners should be instil to better manage their areas to avoid fire spread. On the other side, the larger burnings or burnings in high fire risk areas should require an authorization by the civil protection authorities and should be supported by firefighters or equivalent agents.

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