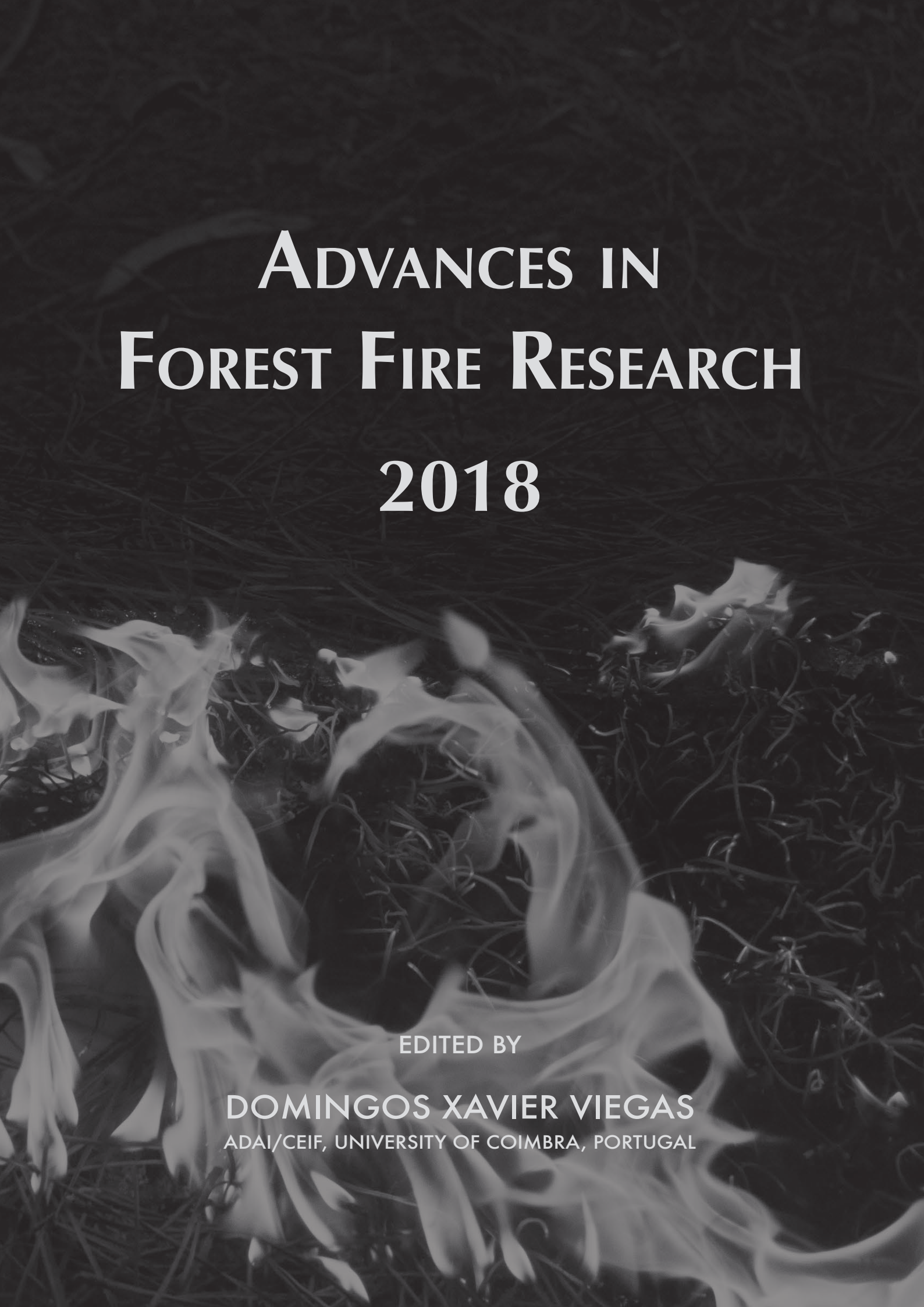
Advances in Forest Fire Research 2018



EDITED BY

DOMINGOS XAVIER VIEGAS

ADAI/CEIF, UNIVERSITY OF COIMBRA, PORTUGAL

Advances in Forest Fire Research 2018 - D. X. Viegas (Ed.)
Chapter 4 – Fire at the Wildland Urban Interface
https://doi.org/10.14195/978-989-26-16-506_79

Carcaixent fire impact against a self-protected WUI zone. Lessons learned

Ferran Dalmau Rovira*; David Caballero Valero; Francisco Quinto Peris
Medi XXI GSA – WUIProtect Consortium, www.wuiprotect.com, {ferrandalmau@medixxi.com}*

Abstract

In June 2016, a forest fire had a head-on impact with some misalignment, but with aggressive local topographic behavior, to the Colonia Santa Marina residential settlement. This settlement had a Self-Protection Plan approved in 2007. The Plan was based on a forest fires protection system whose acronym is WUIPROTECT© (Wildland Urban Interface Defense System) and it included the self-projection planning for previous fire risk, the Owners Community training, fuel management and the installation defensive infrastructure. Both the Plan and the foreseen infrastructure for the nucleus were activated hours before the impact and contributed to the defense of the urbanized area.

With this methodology of operations, on one hand, the risk of affecting population and intervening professionals is reduced by lowering temperature, radiation, secondary foci ignition potential due to short-distance flashes..., and on the other hand, environmental and infrastructures damage is reduced. Obviously, without the intervention of ground means, the result could have been different, in the same way that it would be if aerial means wouldn't join the heli-transported brigades efforts, WUIPROTECT® reduces the intensity of the fire, causing it to reach extinction capacity, emulating in this way what would be focused land-based discharges whenever they are convenient.

Due to the interest aroused by this unusual scenario, in which a developed forest fire impacts a residential area with a self-protection system, it has been considered convenient to proceed to analyze the facts to obtain some conclusions in order to identify the strengths and weaknesses of the system to improve its design, installation and operation.

This document is a summary of the technical report made based on testimonies, photographs and on-site observations of the facts and their consequences. For this purpose, an intense work of interviews with intervening professionals, eyewitnesses and owners of Colonia Santa Marina residential settlement and several expert ground visits to document the events has been carried out.

Keywords: WUI, defensive system, Fire Adapted Communities, Training, Civil Protection, WUIProtect, SIDEINFO, prevention, self-protection, risk reduction

1. Introduction

Colonia Santa Marina residential settlement is located between the municipalities of Carcaixent and Alzira, in Ribera Alta county (Valencia), in Barraca d'Aigües Vives valley, 500 meters from the main population nucleus on the right side of CV-50 road, towards Tavernes de la Valldigna (Figure 1).

According to the analysis carried out in the Self-Protection Plan, the vegetation surrounding in 500 meters, Santa Marina settlement is formed mainly by crops land (515 hectares) and land with forest cover (389 hectares). The forest land is covered mainly by Aleppo pine (*Pinus halepensis*) with close to 100% of covered fraction and plenty of Mediterranean maquis in the underwood. Colonia Santa Marina has 140 plots/properties and according to data compiled for the Self-Protection Plan, and during the summer houses a maximum estimated population of 700 to 900 people, depending on the day of the week. It should be noted that after Self-Protection Plan development, an urban development associated to Santa Marina, called Santa Marina 2, was made and meant a significant increase of the population in the area, although it is administratively segregated. The northern limit of the urbanized area matches with CV-50 road that links Lliria and Tavernes de la Valldigna and from which

the residential area is accessed through the main entrance. A second entrance was added on the eastern boundary as part of the plan to improve the road network in the Self-Protection Plan ant it allows the access to the area from the Convent de Santa María d'Aigües Vives.

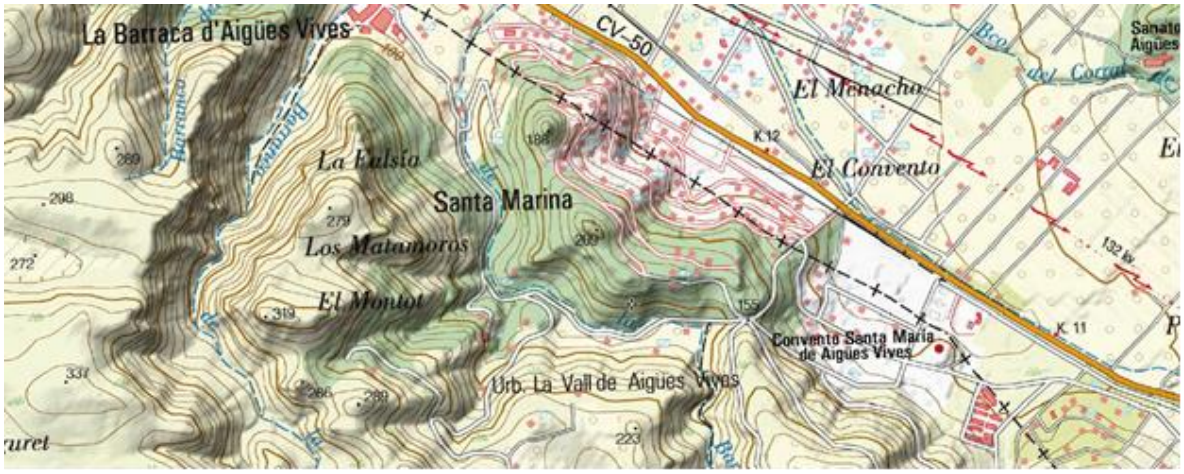


Figure 1 - General topography map of the impacted area. Fire impacts from W (left) to E (Right).

2. Fire analysis

2.1. Weather conditions

At the time and place of the fire origin, the wind predictions were higher than 20 km/h with gusts up to 40 km/h, from general west component and getting slower during the following hours when it rolled to south-west and south component to the end of the day. The breeze at the beginning of the afternoon over the area was blocked by the effect of west component winds with intensities from moderate to strong. During the first moments of the fire, the temperature remained close to 30ºC and the relative humidity below 30%.

According to observation data from the 8300X station of Carcaixent, from the State Meteorogical Agency (AEMET), the wind was blowing from NNW and W component to roll to SSW at nightfall, when intensity decreased significantly. The push of the NW wind in the development of fire's left flank caused it that during the night, with SSW wind, to move towards the Colonia Santa Marina residential area, but with less intensity. On the final hillsides before the impact, the fire ran more because of topography than pushed by the wind.

The observed data by the means of extinction in the place and time the fire started on 16/6/2016 are the following: relative humidity, 25%; temperature, 29,7-38,9 ºC; wind speed: 20,6 km/h with gusts up to 38,9 km/h; wind direction, 280º (W) to 300º (NW). Value ranges between observations and predictions, particularly wind, could be caused by local effects and channelling by ravines and hills of the area.

2.2. Overview of the impact zone

The impact of the wildfire front in Santa Marina took place in different locations between 23:50h on 16/06 and 02:30h on 17/06, affecting almost all the forest perimeter of the settlement during this period. Although there was a decrease on the wind speed towards night, the fire front impacted with some misalignment in three areas where there was presence and continuity of forest fuel on both sides of the road that runs through the La Barsella ravine.

There were up to 3 high intensity wildfire fronts favoured by topography. The rest of the perimeter had a crop field (orange grove) in the lowest part that separated the forest mass. The crop field, which was farmed and maintained, acted as a firebreak at that point, giving a chance for control. In this part

of the perimeter, two fire flanks were opened and ran with 2/3 alignment by the fire relocation in the lower part of the slope. However, in all observed impact cases, the potential behavior was front/flank. The subsequent analysis evaluates the difference of the effects produced in different parts of the perimeter.

Fire managed to get through the defensive line in the southeast area (Picture 2) and in the northwest area (Picture 3). In the case of the southwest impact, it reached the interior of the residential area through the perimeter strip that had been without maintenance for 10 years. In the case of the northwest impact, it is estimated that something similar happened but the flame front could have been powered by the hill effect and the increasing intensity of local wind.

Figure 2 - Impact in area 1 (south-east). Images taken from the position of the Advanced Command Post. In the central part of the right image certain alignment is observed. When fire reaches the top of the slope, it meets the first wetted area by the WUI-PROTECT® and stops its progression. Source: Own elaboration based on Medi XXI GSA images.

Figure 3 - Impact in area 3 (northwest). Images taken from Josep Piera Montagud Street in Barraca d'Aigües Vives. In this area, the lack of maintenance of the perimeter fringe favoured the entry of fire inside the residential area. Source: Own elaboration based on Medi XXI GSA and J.L. Mollà pictures.

2.3. Fire behavior at the impact site.

The fire behaviour on the hillside through which the fire advanced and impacted on the urban settlement, based on direct observation of the forest fire and the analysis of the degree of destruction and severity in the vegetation later on (Picture 4). As mentioned before, towards the night the wind lost intensity and it rolled to a component that aligned with the slopes surrounding the urban core (SW). Both live and dead fuel was, in general, very available, due to previous drying days, due to poor recovery of the previous night, due to the west wind episode and due to the fire desiccant effect that

entered Barsella ravine. With it, the fire that went up from the bottom of the ravine to the urban area, did it from an entry point located at the bottom of the ravine (B) and was realigned uphill pushed by the light wind but getting virulent, consuming all the available fine fuel in some points, in short runs of active crown fire that were generally driven by the undergrowth shrub. From the hillside inspection prior to impact, it can be deduced that fire developed its full potential both on the surface and on the treetops in those short distances, since there was practically no remaining fine fuel and the soil was severely burned, indicator of very high temperatures.

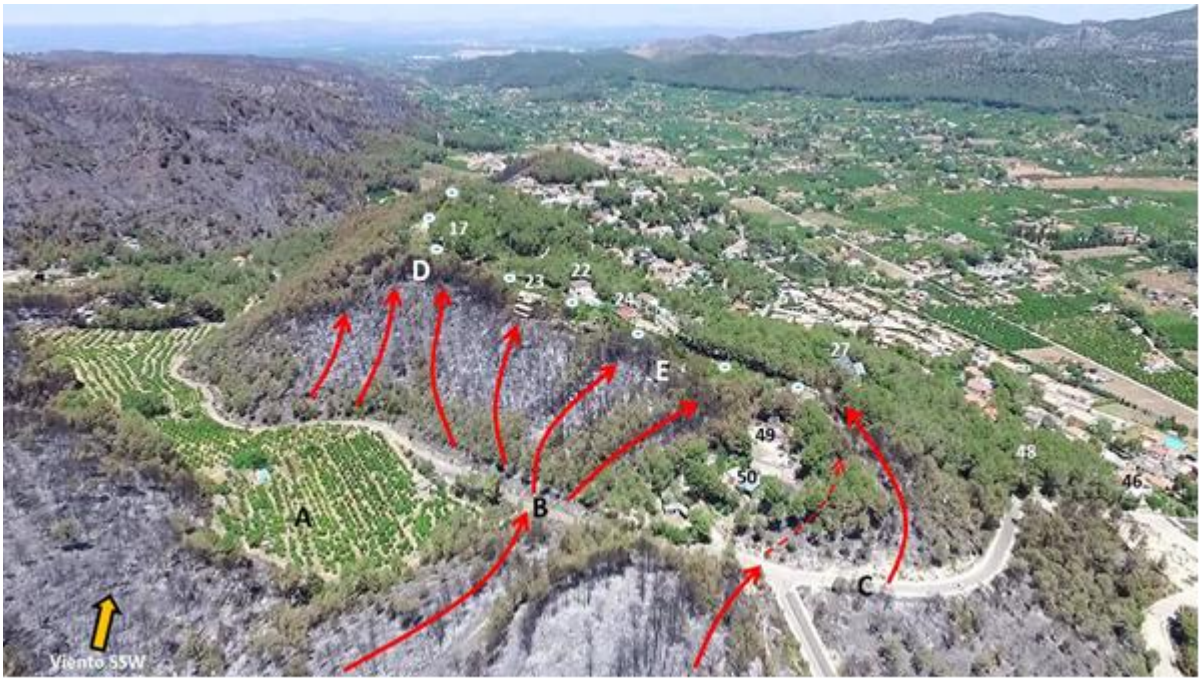


Figure 4 - Aerial view of impacted area after the fire. It shows that crops acted as a firewall (A) and also shows the possible entry point of fire to the SW hill (B), with wildfire front outplacement in very heavy wildfire main spreads to the top (D and E) and a second fire entry point (C) which generated wildfire main spreads too. At the moment of the impact, SW wind had a low intensity. The position of WUIPROTECT® cannons is indicated with circles. It can be appreciated that the house 23 was directly impacted by wildfire main spread head. Source: Medi XXI GSA

It is possible that fire jumped the bottom path of the ravine at some point (C) causing new races on the southern side of the hill, some running under the undergrowth and burning pines and some other more intense climbing treetops in dependent races. It seems reasonable to think that the difference between both behaviours depend on the amount of undergrowth in each point.

2.3.1. Flame length and intensity

As mentioned and observed above, the flame length reached locally between 20 and 30 meters just at the pass of Barsella ravine and on the rise up the hillside. The fuel model described above, which can be seen on the right side of the picture taken before the fire, generated a high intensity flame that made it impossible for the deployed units (Military Emergency Unit, UME) to work in the area. It clearly seems that the wildfire main race through the hillside by the urban area, developed a fire whose intensity was outside capacity of extinction, forcing to defensive maneuvers to palliate the effects on affected houses.

2.3.2. Propagation speed

The fire spread very fast. It is estimated that during the first hours it reached propagation speeds between 50 and 75 meters per minute based on front position measures and the time elapsed since the

beginning, burning more than 1.200 hectares between 16th and 17th of June (despite being at night) affecting finally 2.300 hectares until day19th.

2.3.3. Smoke environment

During all defensive operations the intervening crews were subjected to an intense smoky atmosphere and to a rain of short and long distance flashes although the fact that impacts occurred at night helped to avoid in part more secondary ignitions due to the increase relative humidity and the released water from the system in the perimeter, according on testimonies collected from the operation.

2.3.4. Hot ashes range and secondary fires

In the detailed post-fire inspection (made in the days immediately following the impact) a constant ash layer was observed through the streets of the residential area. This fact indicated that urban nucleus was subjected to a constant rain of ashes that arrived extinguished to the ground because by its size and mass the complete combustion happened in its flight.

Notwithstanding the foregoing, at least 3 secondary fires were documented in the first 200 meters from the main front in the impact zone. There is no record of any further jump of larger particles into the population centre that would result in secondary fires. According to testimonies gathered by the Fire Department of Valencia Provincial Consortium, the hot ashes that jumped the perimeter extinguished when they met previously wetted vegetation.

3. WUI-PROTECT® system in Santa Marina

As explained in annex 1, WUI-PROTECT® system consists of four components, namely: fuel management and perimeter belt, training and education, hydraulic cannon system and planning. This section focuses on the hydraulic cannon system component, specifically at the moment of the impact the installation was as follows:

Monitoring location and features: the hydraulic system of Santa Marina is composed by 15 monitors distributed on 5 sectors (3 monitors/sector) numbered from 1 to 5. Picture 44 shows its association with 3 impacted areas by wildfire's front. 18 monitors were initially proposed (one more sector) but this sixth sector was not implemented for budgetary reasons. This system works at 6-7 Kg/cm^2 with a range per monitor between 45 and 50 meters. At the base each column there is a fast-charging hydrant (15 in total). The overlap between the areas of influence of each cannon is between 15 and 20%. Each cannon irrigates between 6.400 and 8.000 m^2 with a rainfall between 7,6 and 9,3 l/m^2/hour.

3.1. Sequence of events at WUI-PROTECT® operation in Santa Marina

At 17:44h, the people in charge of the Self-Protection Plan of the Colonia Santa Marina residential area got in touch with the Advisory Committee (figure include in the Plan) specifically there was a first contact with technicians who wrote the Plan to consult on the activation of WUI-PROTECT® hydraulic system in Santa Marina. The first pictures received from the impact area were taken by Self-Protection Plan members of the urban nucleus. (Pictures 5 and 6)

After consulting municipal officers and gathering information on the weather conditions, fire situation and its expected evolution, instructions to turn on Santa Marina's WUI-PROTECT® system were given by the Advisory Committee. Immediate start-up was confirmed at 6:00 p.m. on 06/16/2016, both through the conversations held and through the graphic documentation compiled.

The recommended discharge (operation) parameters were to contribute to each sector (from 1 to 5) between 15 and 20 minutes of water and successively repeat the pattern to ensure a homogeneous contribution of wetting to the entire perimeter.

Figure 5 - Image taken on 06/16/2016 at 8:40 p.m. from Barraca d'Aigües Vives. It shows WUI-PROTECT® monitors of sector 3 providing water to the perimeter before the arrival of the flame front. Source: Vicent Vila.

Figure 6 - Picture taken at 9:01 p.m. from Barraca d'Aigües Vives. It shows WUI-PROTECT® monitors of sector 3 as they continue supplying water, in this case outwards, before the arrival of the flame front. It shows that the water reach is less outwards due to strong upwind. However, this effect was offset with a bigger water inner scope. More water inside and less water outside. Source: Vicent Vila

4. Analysis of the observed effect of operations on fire spread

At the moment of the impact, the flame front locally developed its full potential, as showed by the traces observed in situ after the fire (white ashes due to its complete combustion, totally consumed treetops and so on). In the last meters of the fire run there is a significant reduction in the intensity and, therefore, in the speed of fire, especially in the areas with the greatest amount of water contributed by WUI-PROTECT®. In fact, a complete stop of the fire progress is observed in some of the areas exposed to the fire front, which has come to be called "green island effect", as evidenced by the case of house 23 that, despite being on the most exposed slope, it has not suffered significant damage. In the post-fire eye inspection, the authors were surprised at seeing such a remarkable gradient in the fire behaviour in the local run up the slope: from seeing a burned out ground and treetops with fine material completely consumed to see vegetation barely scorched in a narrow stripe and intact green vegetation a few meters away. Operations of deployed media were favoured by being able to work in some impacts whose flame front were in extinction capacity. With all this, it can be deduced that WUI-PROTECT® action created in part of the impacts a fire behaviour that was within the security margins

for both flame intensity and secondary outbreaks that could end up in potential fires. WUI-PROTECT® system effect emulated aerial means unloading water during hours in the impact zone. The system had no effect on the smoke.

5. Discussion

Carcaixent wildfire did not badly damaged population centers due to the combination of previous actions and the sequence of events that took place between June 16th and 17th, 2016. All affected population centers had developed a Self-Protection Plan and part of the inhabitants had received training in fire defense. Although the involvement in this kind of activities doesn't usually exceed 20% of the population, the fact of having a group of neighbours from the affected area with the necessary training on fire defense, was clue to an effective defense of Santa Marina urban nucleus. Previous training sessions were useful to have communication channels open and current. On the other hand, the mechanisms established in the Self-Protection Plan served to coordinate actions among Plan managers and external aid. Thanks to the previous work, evacuation takes place without incident and part of the neighbourhood, knowing how to act, led their own self-protection.

One of the elements that is considered necessary to improve in Santa Marina is the automation of the system. While communication technologies and automatism have been implemented on projects developed later, it has been proven that leaving the activation of the system to the Community of Owners, increases the likelihood of human error that could compromise the effectiveness of the system. It is considered that the system was activated sufficiently in advance. The problem was not the activation itself, but water consumption management. Since advisory committee members were not in operation area all the indications was given by phone and messages. By not having a complete view of the situation, Advisory Committee requested to activate the system too soon. This is not a negative fact in itself. In fact, it has always been explained that the system would be more effective the longer the advance with which it was activated. Fire Department of Valencia Provincial Consortium middle managers were the ones who determined in situ which sectors to activate at all times, correctly covering the entire perimeter.

The prescribed operations parameters consist of consuming 50% of the water before the impact and saving the rest by the time of the impact. This parameter was not respected for various reasons related to the amount of information in this kind of events. For this reason, the idea of the need to implement automatisms (water discharge sequencer, probes for calculating water reserves) is reinforced to avoid human errors in the operation.

6. Conclusions

From the collection, analysis and discussion of the data and information exposed about Colonia Santa Marina forest fire, different conclusions can be deduced in order to improve protocols, methods and devices of WUI-PROTECT® wildfire defense system.

According to the data collected and the information processed throughout the preparing of this report, the combination of fire fighting crew's work and WUI-PROTECT® system contributed to significantly reduce damages inside Santa Marina urban area. As an initial conclusion, it should be noted that, although the results could have been improved, given the existing conditions, the work carried out before the fire in the four areas detailed on the methodology (developed over the ten years that the system has been installed) has been essential to provide effective self-protection against the wildfire that affected the urban nucleus.

The WUI-PROTECT® Wildfire Defense System has fulfilled its goal for which it was designed, contributing significantly to reduce damages derived from the direct impact of a high intensity wildfire, even though it was not the worst possible scenario (for example, if the fire had started 3 hours earlier

and had arrived in full alignment and potential). However, from this report we have laid the foundations for the improvement and evolution in order to offer better solutions in the future. Some conclusions are detailed below by operational areas in order to organize the knowledge acquired throughout the process.

- Monitors, as a hydraulic part of WUI-PROTECT® defense system, have fulfilled their role of reducing intensity and speed of the flame front approaching an urban nucleus, in order to create an environment for suppression and defence operations in which fire is within extinction capacity in most of the perimeter. In the areas where it has been totally effective, working conditions have improved. (Picture 6)
- For that goal, WUI-PROTECT® monitors have served as support on fire control and extinction operations, similar to continuous water discharges from planes, in a particularly important area (an urban settlement inside the impact area) and just at the right time (especially during the night, without support from aerial means).
- According to testimonies of the operation members, WUI-PROTECT® monitors created a safer working environment for ground operations, especially by reducing the temperature. However, as a collateral effect, the soil had worst conditions in places where water accumulated, mud was formed and surface run-off was caused. WUI-PROTECT® had no effect on smoke.
- According to remains and severity analysis, everything seems to point out that WUI-PROTECT® system water posture could have contributed to reduce the intensity and the speed of propagation of a fire front that progressed over treetops in its final strech to Colonia Santa Marina. In areas where there was more water supply, it is quite clear that WUI-PROTECT® system contributed to stop the fire's progress.
- Everything seems to indicate that there is a direct correlation between the amount of water thrown and the level of damage to the vegetation. Those points in which the monitors did not operate (due to water pipes destruction), the defense and extinction operations were conditioned and also the degree of the impact on houses and vegetation presented greater severity. However, this observation must be tested in future research and development actions.
- Secondary fires did not advance inside the action range of WUI-PROTECT® monitors. This avoided internal ignitions improving the safety of the intervening units and defending buildings in the most exposed areas.
- WUI-PROTECT® water distribution on the vegetation and buildings created a “green land” effect that contributed to the fire control and to reduce building damage. Houses inside the action range of WUI-PROTECT® monitors showed no damage or damage was observed in those areas where water did not arrive. The shadow effect of vegetation and the structures themselves must be considered on future system designs.
- The total amount of water sprayed by WUI-PROTECT® monitors could have been better distributed in the different sectors; also, and according to the results on vegetation, so much water would not have been necessary to meet the objectives of reducing the intensity and speed, thus bringing the wildfire front to a scenario of extinction capacity. The sequence and the timing of water distribution was not optimal nor was it sufficiently coordinated with ground extinction operations.
- WUI-PROTECT® monitor operation is one of the four components to protect urban nucleus against wildfires. Despite the positive effect observed in controlling the progress of the fire to Santa Marina, its effectiveness could have been multiplied if the protection strip had been

perfectly maintained, particularly at the points where the fire was able to pass into the urban nucleus. This reinforces the thesis developed by project managers. The combined action of the four lines of work (Planning, Fuel Management, Hydraulic and infrastructure, training) is fundamental. It is necessary for the future to improve the design of these defense spaces to favor the effectiveness; they must necessarily be accompanied by viable maintenance plans and assumed by the owners.

- Sections of pipe network potentially exposed to radiation and in contact with fire could cause partial or total failure of the system by the degradation or destruction of the same ones. The presence of water inside the pipes reduces or prevents such destruction as has been demonstrated. However, previous operation and hydric contribution improved conditions during the impact.

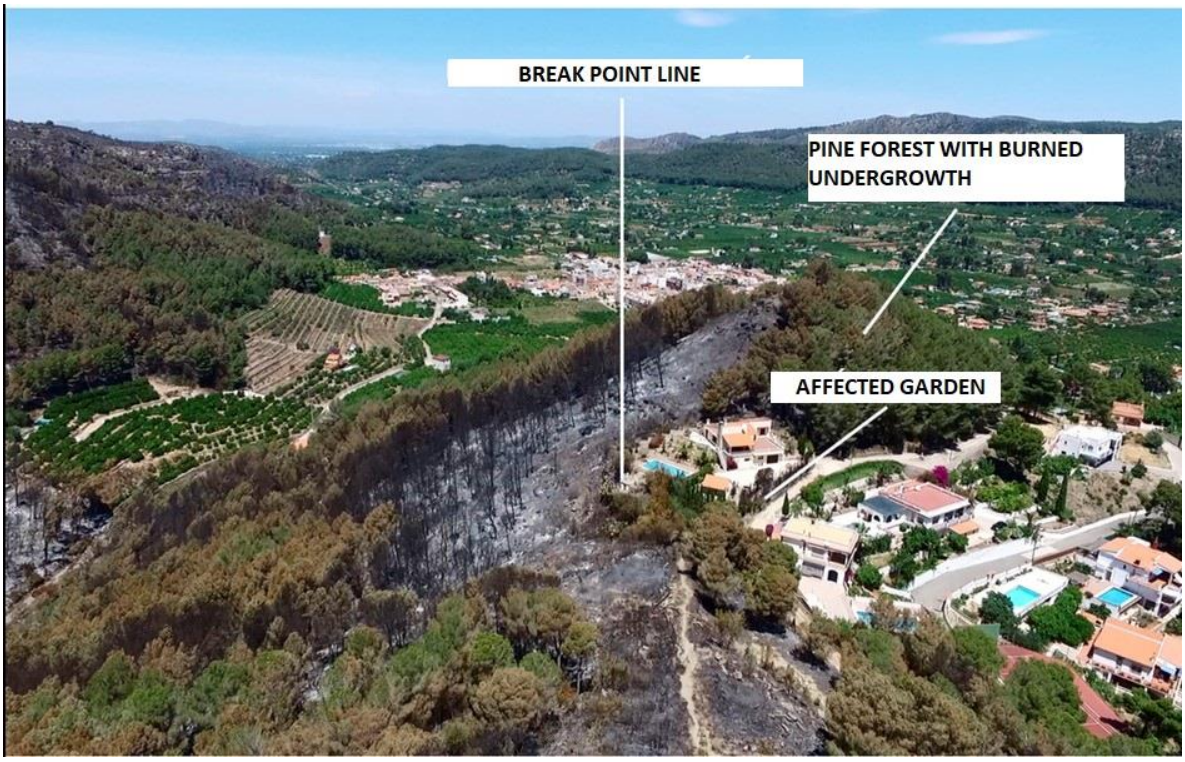


Figure 7 - Break point of the water pipe in the area of impact 3. It has been identified from the review of the entire istallation in the perimeter. Source: Medi XXI GSA

The WUI-PROTECT® design in Santa Marina is adjusted to the defensive needs of the residential area since it is not planned as an extinguishing tool, although it has a broad range of improvement on both design and execution of actions that will be based on the knowledge acquired after the Carcaixent fire, among others.

Hydraulic installation is part of a set of defensive actions (planning, fuel management, infrastructure and training) aimed at improving the self-protection capacity in urban forest interface environments with high risk of fire. The second line of protection is provided by terrestrial means. That has always been the prescribed working methodology, and in this case it has shown its effectiveness.

With this operation methodology, on one hand, the risk of harming population and interveners is reduced by lowering temperature, radiation, ignition potential of secondary fires caused by short distance spotting. On the other hand, damage is reduced at both environmental and infrastructural level. Logically, without the intervention of the terrestrial media, the result could have been different, but in the same way that the heli-transported brigades base their effort on the work combined with the

aerial means, WUI-PROTECT® reduces the intensity so that the fire enters in extinction capacity emulating what would be focused land-based discharges where it is convenient at each moment.

The self-protection on areas at high risk of wildfire can not be a should not be a right, it must be a shared obligation betwen public administration, that must generate the necessary framework to adopt the actions, and individuals whose interests, properties and lives will be at risk at the time of the incident. It must be clearly stated that defending wildland-urban interface areas puts the lives of professionals at risk on many occasions. And the lives of the interveners are also above the defense of the goods. As long as the interveners lives are put at risk to defend private properties and the defense of environmental resources is mortgaged, the situation becomes socially, economically and environmentally unsustainable.

It has also been shown that investment in preventive / defensive measures can be much more profitable than fire extinction. And this is not just based on investment on population centers. It should also be based on the agroforestry management of their surroundings. When measures on wildland-urban areas and their immediate surroundings are prepared to receive the fire impact, control and firefighting operations can be carried out normally without consuming public resources to defend private properties. "Crews kidnapping" effect at interface areas is known among the wildfire professional sector. This way, the fact of prioritizing the defense of populated areas leads to a neglect of forest and rural areas. This ends up having as a direct consequence that public or private areas that generate benefits for the society as a whole (CO_2 and other greenhouse gases sinks, oxygen production, landscape, hydrological cycle…) are unprotected because spaces that should be self-protected (that is, protected by their own means) are using this protection.

The cost per owner for the period 2006 – 2016 was 707,46 euros. Defended urban nucleus has 140 plots. If the investment per plot had been a bit higher, protection would have been clearly more effective. Having invested 1.000 euros per owner would have reduced fire damages and it would have saved the expense that now involves recovering it to a normal state, both in gardens and in the few damaged infrastructures. This also includes damaged pipes from WUI-PROTECT® itself, obviously. As an example, Fuencaliente's wildfire (on 2009) showed that the ratio of costs of firefighting to those of subsequent recovery was 1-6.