UNIVERSITAT POLITÈCNICA DE VALÈNCIA

ESCOLA POLITÈCNICA SUPERIOR DE GANDIA

Grado en Ciencias Ambientales

"Cómo afectan los incendios al suelo y a la vegetación de la región valenciana"

TRABAJO FINAL DE GRADO

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GANDIA, 2019

Acknowledgements

I would like to thank my tutor Jan, who has given me all his help, my tutor at my home university, Leticia, who has helped me in the search for information, and of course, all my friends and family, for always being there to support me and encourage me to outdo myself.

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1. Introduction

In the Valencian Community, fires are very common, and 70% of them have their direct origin, as negligence or intentional; and indirect by the territorial model that exists, such as, for example, the abandonment of rural areas and an excessive accumulation of forest vegetation, which translates into an abundant fuel available to burn (RUIZ, 2014).

It is therefore vitally important to know the negative effects of forest fires and how they could be improved to prevent them, as vegetation in the Mediterranean forest offers great benefits.
In terms of water, it improves subsoil infiltration, regulates its availability and improves its quality, and protects against flooding by regulating river flow (RUIZ, 2014).
In the air it provides oxygen and reduces atmospheric pollution produced, in part, by emissions from CO_2 (RUIZ, 2014).
The soil is protected from erosion by reducing the impact of rain and is retained by the roots. In addition, vegetation aerate the soil and create a suitable environment for soil microorganisms (RUIZ, 2014).
It also harbours living things, shelters them and feeds wild species (RUIZ, 2014).
As for temperature, it reduces contrasts, avoiding thermal extremes (RUIZ, 2014).
And finally, to the economy and society, it contributes raw materials such as wood, cork and resin, mushrooms, truffles, pine nuts... It is an attraction for sport, recreation and leisure, it forms a rich and diverse landscape that forms part of its own heritage, and it is the livelihood of many people, directly or indirectly (RUIZ, 2014).

Therefore, due to the geographical location of Valencia and the great abuse that has occurred in these soils (Cristina Montiel Molina), forest fires have become a major problem for the ecological balance and landscape of the area (MATARREDONA, 1996), and we must act against it.

2. Natural environment of Valencia region

To talk about the natural environment of Valencia, points such as soil, relief, vegetation, weather, anthropic action and ground uses, respectively, will be addressed.

2.1. Soil

The Mediterranean environment in which Valencia is located, has some climatic characteristics intermediate between the climate of arid, subtropical dry and temperate oceanic climates, being the degree of affinity or kinship greater with the first than with the second and the third, respectively. For this same reason, the Mediterranean landscapes have a great richness of soils, as corroborated, for example, in the Soil Catalog of the Valencian Community (FORTEZA, 1995). Specifically, the soil taxonomic units represented in the region of Valencia are: Fluvisols, Gleysols, Regosols, Leptosols, Arenosols, Cambisols, Camisoles, Solonchaks, Kastanozems, Chernozems, Phaeozems, Luvisols, Andosols and Anthrosols.

Delve into the most abundant soil type in the Valencian Community, we would find the Cambisols. These are very little evolved soils, but enough to show a subsurface horizon with change of color, structure or texture, which is the result of edaphic processes of in situ weathering.

Figure 1. Edaphic profile of a Cambisol soil.
Authors: Iván Alfonso Contreras Saura and Isabel Domene Navarro

2.2. Relief

The Valencian Community is formed by three major relief units: the Iberian mountain range, part of the Betic mountain range and the depression of Valencia (ENVIRONMENTAL AGENTS OF THE GENERALITAT VALENCIANA).

On the one hand, the Iberian mountain range occupies the northern and central part of the territory, situated in a manner clearly parallel to the coast, following an approximate direction from the northwest to the southeast, from the Port of Morella, to the north, to the Massif of Caroch, to the south (ENVIRONMENTAL AGENTS OF THE GENERALITAT VALENCIANA).

On the opposite side, particularly in the southern third, appear almost all of the lands of Alicante and the south of the province of Valencia, the final foothills of the Betic mountain ranges, which, following a southwest-northeast direction fold to the north to build with the Iberians in the mountainous massifs of Caroch and Monduver (ENVIRONMENTAL AGENTS OF THE GENERALITAT VALENCIANA).

Finally, to the east, and relatively embedded by the two units of relief above, there is a third, the depression of Valencia, without almost orographic elevations, and that is specifically limited by the mountains of the Calderona to the north, by the mountains of the Corbera to the south and by the buttresses of the Central plateau that penetrates in the region until a little more to the east of Requena by the western band (ENVIRONMENTAL AGENTS OF THE GENERALITAT VALENCIANA).

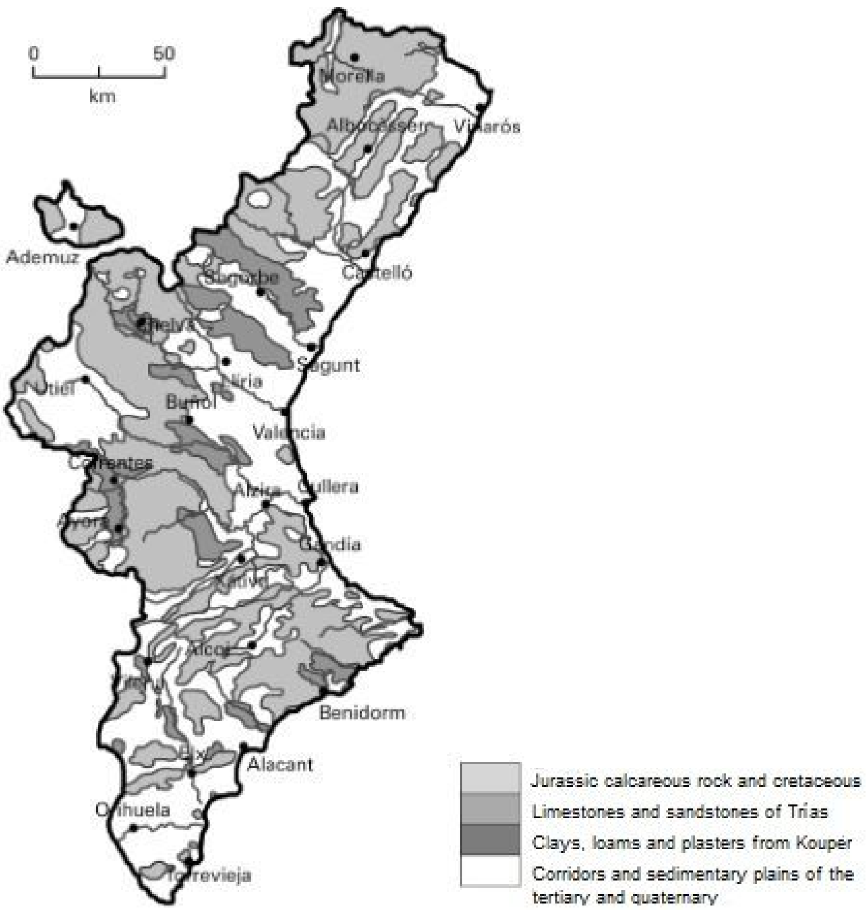

Figure 2. Geological and morphostructural map.
Source: Geography of Spain. Volume 10.

2.3. Vegetation

Historically, the Valencian Community, has been a territory that has supported the passage of many cultures and subjected to an intense exploitation, which has caused serious alterations in the vegetation cover. Therefore, there are currently few examples of well-structured plant formations, especially at the forest level. It is common in the landscape to dominate the scrubland and bushes and the wooded stratum is absent (ENVIRONMENTAL AGENTS OF THE GENERALITAT VALENCIANA).

The factors that most directly influence vegetation are normally of a climatic, edaphic, topographical or biotic nature. The most limiting factors in this zone are the lack of water in the arid regions, and the excess of salt in the coastal halophilic zones. In the Mediterranean world the minimum rainfall coincides with the maximum summer temperatures (COSTA, 1986).

As for botany, it is common characteristic of the Valencian vegetation adapted plants to support the aridity of the territory, with coriaceous leaves and little vegetal surface, in order to diminish the transpiration in the possible measure (ENVIRONMENTAL AGENTS OF THE GENERALITAT VALENCIANA).

The coastal areas are influenced by the Mediterranean, and this contrasts with the hinterland with its harsh conditions. On the other hand, the humid influence of the Catalan lands, that is to say, the north, and the aridity of the Alicante lands towards the south, determine spectacular contrasts that provide the Valencian Community with edaphic, orographic and climatic conditions that entail the presence of a flora and, therefore, of a very varied vegetation (COSTA, 1986).

In the Valencian Community there are 20,355 species different cataloged (registered in 19/05/2019), which supposes more than 20% of the biodiversity of all Spain and one of the territories with greater biological diversity in Europe. Although there is a lot of biological wealth to discover and this is much greater than what is currently known (CENTENO, 2011).

In the Valencian area, as an example of potential vegetation are the carrascales, while as permanent vegetation are the poplars and elm trees along the rivers, among others (COSTA, 1986). The following Figure 4 specifies the dominant forest species in the Valencian Community. The *Pinus Halepensis Miller* (1786) is one of the most common and will be discussed later.

Figure 3. *Pinus Halepensis Miller* (1786).
Author: Simón Fos. Source: official website of Valencian Generality.

Dominant forest species of the Valencian Community

Pinus halepensis
Pinus nigra
Pinus pinaster
Pinus sylvestris
Juniperus communis
Juniperus oxycedrus
Juniperus thurifera
Quercus ilex
Quercus suber
Quercus faginea
Quercus coccifera
Ceratonia siliqua
Rosmarinus officinalis
Thymus spp.
Cistus spp.
Ulex, Adenocarpus, Spartium Retama, Sarothamnus, Genista, Colutea spp.

Figure 4. Dominant forest species of the Valencian Community.
Source: official website of the Generalitat Valenciana. Ministry of Agriculture, Environment, Climatic Change and Rural Development.

2.4. Weather

The location of the region of Valencia is in the western part of the Mediterranean Sea, under the marked influence of this, and taking into account that there is no point in the territory that is more than 100 km away from the sea, except those of the Rincón of Ademuz. As the general characteristics are common, we must look at other factors, such as relief and altitude, the reasons to distinguish between different climatic sectors within this region (ENVIRONMENTAL AGENTS OF THE GENERALITAT VALENCIANA).

The precipitations are scarce and present two maxima: one in autumn and another one in spring. Temperatures reach their maximum in July-August, and minimums in January-February. The prevailing winds are those of the west, and although they come from the Atlantic they are dry, since when crossing the peninsula they lose their humidity and still they become more dry by the effect foehn, when having to descend the step of the Plateau towards the littoral zone (ENVIRONMENTAL AGENTS OF THE GENERALITAT VALENCIANA).

Within this climatic environment, distinctly different stations occur. The summer is dry due to the widespread influence of the Azores anticyclone that prevents the entry of Atlantic storms. The only precipitations are of stormy local character, by sudden ascension of reheated air. However, in the littoral zone, and due to the breeze regime, the relative humidity is high (65-75%) and sticky due to heat (ENVIRONMENTAL AGENTS OF THE GENERALITAT VALENCIANA).

ANNUAL AVERAGE PRECIPITATIONS

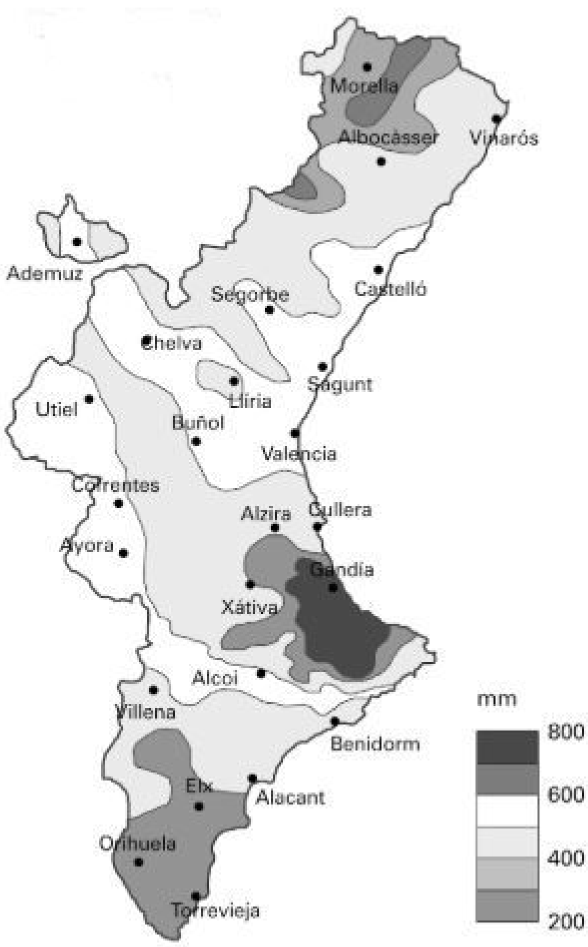

Figure 5. Map of average rainfall in the Valencia region.
Source: The Valencian Space. A geographical synthesis.

The average temperatures of July-August, range between 24-26°C on the coast, with little amplitude between day and night. In the interior, the average oscillates between 21-23ºC, but the difference between day and night is much higher, resulting in hot days and cool nights. The lower relative humidity means that the heat inside is not as sticky as in the coast (ENVIRONMENTAL AGENTS OF THE GENERALITAT VALENCIANA).

In autumn temperatures drop with averages of 22°C in September, and 14°C in November on the coast, and 18 and 10°C, respectively, in the interior. There is also a greater probability of precipitation that does not always arrive. The Atlantic storms affect little to the regions, except in the case of focusing on the Gulf of León or between the so-called route of Gibraltar. The rains usually become temporary storms when they are associated with the presence of cold drop in height over the southwestern Mediterranean or the Maghreb and there is an abrupt rise of hot and unstable air. Then the storms penetrate the southeast, hit the mountains and discharge huge amounts of water, causing floods and floods (ENVIRONMENTAL AGENTS OF THE GENERALITAT VALENCIANA).

In winter the dry weather caused by the anticyclonic influence returns to dominate. The thermal differences between the littoral and the interior are felt with greater intensity. On the coast it oscillates between 9-10°C and frosts are rarely registered. In the interior it is lowered to 3-5ºC and frosts are very frequent. Very rarely, an inversion of continental polar air can occur and frosts and coastal areas are not fought (ENVIRONMENTAL AGENTS OF THE GENERALITAT VALENCIANA).

Finally, spring assumes a rigid recovery of heat and humidity, since April and May are usually the rainiest months of the year, after October. However, the risk of frost is still important and fearsome in the valleys and closed basins of the interior, in whose lower parts the cold air usually stagnates on clear nights, causing a thermal inversion and, sometimes, catastrophic frosts for the crops (ENVIRONMENTAL AGENTS OF THE GENERALITAT VALENCIANA).

ANNUAL AVERAGE TEMPERATURES

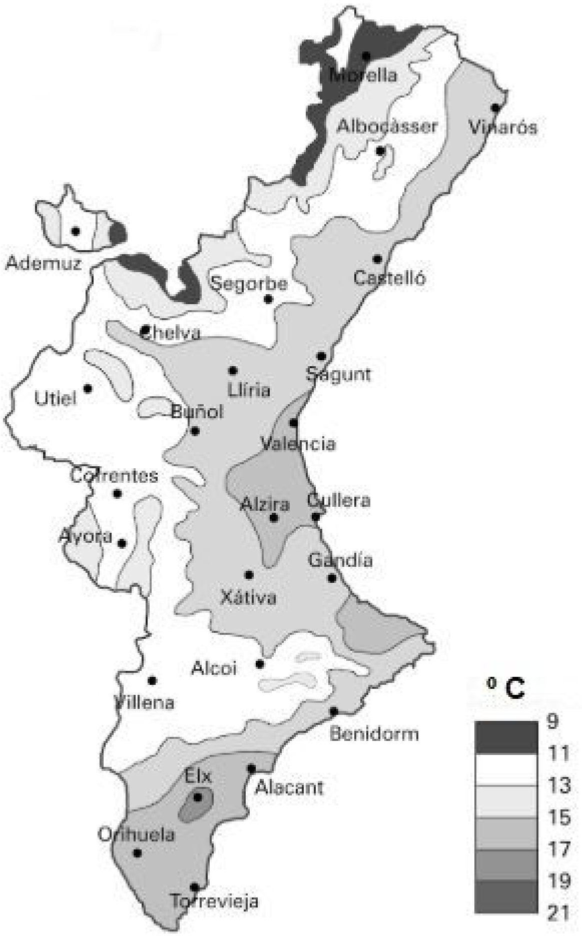

Figure 6. Map of average temperatures in the Valencia region.
Source: The Valencian Space. A geographical synthesis.

2.5. Anthropic action

There is no doubt that today man is the main transformer of vegetation, since, in addition to the classic transformations derived from grazing and agriculture, there are those that make possible the technical means at his disposal, which allow him to urbanize, cultivate and repopulate areas in which until a few years ago natural vegetation was conserved. In addition, it is necessary to add the provoked fires, more and more frequent, and the contamination and the general degradation typical of the hyper exploitation to which the environment is submitted.

Man has profoundly altered the natural environment: agricultural and forestry exploitation, silvopastoral and urban activities, among others, have damaged primitive vegetation and have introduced serious modifications to the landscape, so it is often not easy to recognize

even the potential vegetation of the territory, such as the existence of a kermes oak with palmetto or on an elm.
The agro-livestock pressure has decreased strongly, which has generally led to an increase in the amount of fuel present in these systems and, therefore, an alteration of the landscape structure (loss of fragmentation and/or diversity) and of the fire regime. As a result, the number of fires, and in particular the number of large fires, has increased in recent decades in the Mediterranean (MORENO, 1998).

An example of alteration of the ecological conditions inherent to the stability of the forest as a consequence of anthropogenic action is the felling of a forest or a fire. This entails, among other effects, an increase in light, a higher temperature due to increased insolation, a loss of humidity, a lower incorporation of organic matter into the soil, etc. All this leads to the disappearance of some plants and the development of others that will form other types of vegetation replacing the climax. That is to say, the so-called stages of substitution appear, formed by transitory secondary communities. After these two destructive actions, the vegetation has a natural tendency to recover until reaching the stability of the potential vegetation or climax. This regeneration is also done following fixed dynamic stages, which are followed to regenerate the primitive vegetation.

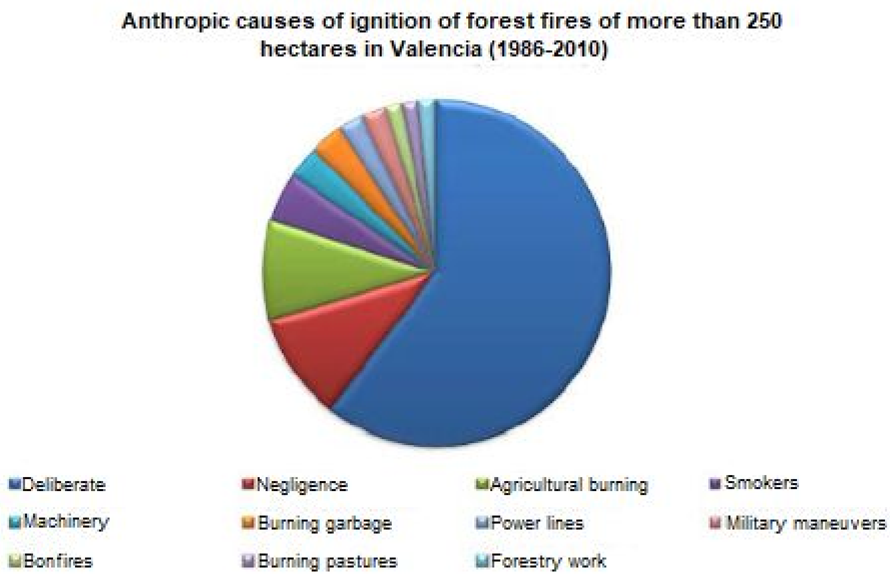

Figure 6. Graph of the anthropogenic causes of ignition of forest fires of more than 250 hectares in Valencia (1968-2010). Author: William Hernández Ramos. Source: Ministry of the Interior.

Figure 6 shows the different causes of anthropogenic ignition of forest fires that have burned more than 25 hectares from 1986 to 2010 in Valencia. As can be seen in this figure, the vast majority of fires are intentional. This is followed by a misuse of fire such as negligence or bonfires.

3. Natural conditions determining forest fires

The progression of forest fires is limited by a number of factors. Some are biological and depend on the composition, structure and arrangement of the plant mass. The vegetation of Valencia is a Mediterranean vegetation, therefore there are species adapted to the environmental dryness (presence of thorns, decrease in the size of the leaves, high content of resins, lack of water) or predisposed to reproduction stimulated by fire (rapid after-fire sprouts, in the case of kermes oak, positive germination of heather and rosemary, or even the rapid spread of seeds in the pine forests). These xerophytic and pyrophytic characteristics of Mediterranean species facilitate the appearance and spread of forest fires (MATARREDONA, 1996).

On the other hand, the influence of climatic parameters is fundamental, especially the presence, intensity and direction of the wind that, in extreme cases (ponents) supposes a constant and violent contribution of oxygen that acts as fuel in the process. In addition, the degree of atmospheric humidity and the vegetation itself must be considered, taking into account that part of the fire's own heat energy is used to evaporate environmental water and plant tissues; for this reason, rain can be considered, in the months prior to summer, as a risk factor for the proliferation of scrub. In the same way, the heat waves can also be considered as detonating agents of the process, especially when accompanied by drying western winds (MATARREDONA, 1996).

Finally, the topographic factors determine the front of fire progression and determine its speed of propagation, since these events advance uphill in the direction of the prevailing wind; therefore, abrupt areas will be more prone to fires than flat spaces (MATARREDONA, 1996).

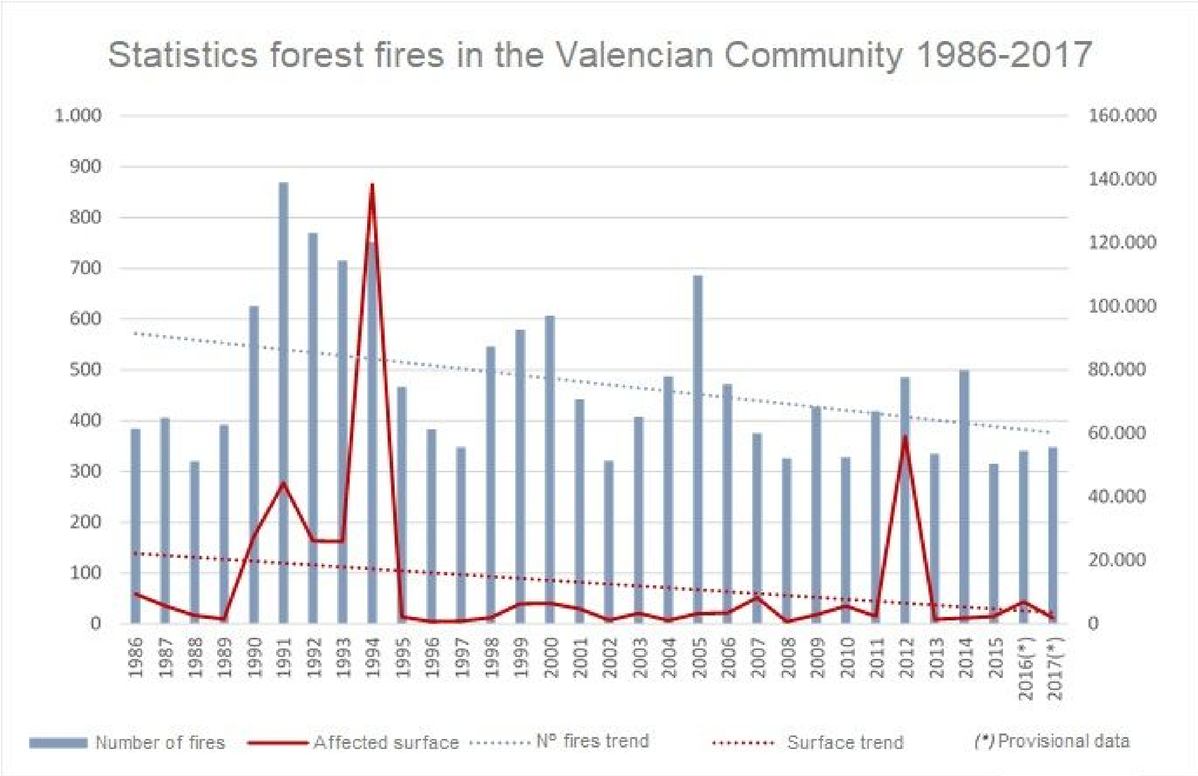

Figure 7. Statistics of forest fires in the Valencian Community between 1986-2017. Source: official website of the Generalitat Valenciana. Ministry of Agriculture, Environment, Climatic Change and Rural Development.

4. Factors that increase the risk of fires

During history, the Valencian forest lands have been exploited and eroded, and as a consequence of this continuous degradation, they are still very vulnerable to forest fires.

The environmental conditions to which the Valencia region is exposed are of a Mediterranean character. Forested areas have had serious problems of regeneration, both by climatic parameters and by the uses and activities to which they have been subjected. The abandonment of farms and traditional land uses, rural depopulation, the proliferation of unstable biomass, access to natural areas through tracks, the rupture of the agro-silvo-pastoral balance by forest policy and the poorly received reforestation policy by the rural population, there are sufficient reasons for how the footprint in the anthropic field has manifested itself increasing the risk of the increase of forest fires.

As it implies the abandonment of farms and traditional land uses, and the activities that involved, such as the collection of firewood, the cleaning of the forest, and the obtaining of charcoal, which previously supposed a great benefit if performed in a structured way, when stopped practicing, has undoubtedly contributed to increase the rate of combustibility of the forest masses and thus to increase the risk of fire.

The process of the net decrease of the rural population and the abrupt demographic change, is another factor that has a negative influence. The lack of rural population and the increase in the rates of aging have affected the traditional maintenance of agriculture and forestry in the area (MATARREDONA, 1996).

This destruction of the social organization and of the agrarian exploitations (MATARREDONA, 1996), has been translated in a reduction of the agricultural space, in a diminution of the variety of cultures own of the traditional system, and in the abandonment of ancestral agroforestry practices that contributed to conserve the soil and to clean the forests of vegetal residues (MUÑOZ, 1986).

The decrease in human pressure in the mountains is having immediate consequences on the dynamics of the landscape. The old terraced slopes, now abandoned, have been subjected to a process of invasion by herbaceous and scrubland, and a new geomorphological dynamic. On limestone soils, typical of these abandoned fields, it is common the presence of a clarified, sometimes rachitic shrub, consisting of rosemary, thyme and aliaga, among others, which, in cases of greater density, constitutes a high risk for the propagation of the fire (MATARREDONA, 1996).

Private property is another factor. There is information on the intervention of farmers to promote the growth of pastures, or that of farmers to expand the farming plots. There are also negligence related to burning of margins or brushwood, burning of landfills, carelessness of hunters or hikers, among a long etcetera (MATARREDONA, 1996).

Large number of fires start at night when the human presence is less and the climatic parameters are not those of extreme risk; however, the highest frequency occurs in the central hours of the day (from 12 a.m. to 5 p.m.), coinciding with higher environmental temperatures, or even, in the case of negligence, with a greater human presence. On the other hand, the concentration in the urban centers of the rural population has deprived the mountain of spontaneous security guards (MATARREDONA, 1996).

The increase in human presence on weekends and the phenomenon of recreational activities in the mountains have also increased access to forest areas. And the fashion of the

4x4 (false tourism of adventure), has contributed to increase the risk, of unprotected areas that were previously safeguarded by their isolation (COLMENAR, 1985).
Finally, we must mention the rupture of the agro-silvo-pastoral equilibrium, with a forestry and reforestation policy that has generated a bad atmosphere among the rural population, in other times "true guardians" of these montane spaces (NAVARRO-XANDRI, 1995).

5. Landscape impacts and the ecological balance

The negative impacts of forest fires have immediate consequences for the conservation of the forests and for the maintenance of the ecological balance (MONTIEL, 1990).
The repercussions caused by these adverse effects are: the destruction of the vegetation cover, especially in pine fires that produce a large amount of heat that makes regeneration difficult; the lack of protection of the soils and the reduction of their porosity and, therefore, of the water infiltration and retention capacity; the reduction of water availability, the alteration of edaphic conditions and the distortion of the hydrological cycle. In addition, we should also consider the increase in the albedo of the surface of the forest, due to the ash and, consequently, the increase in heat absorption and the potential for evaporation (MATARREDONA, 1996).

Regarding the decrease in soil infiltration capacity, surface runoff becomes more important in areas affected by fires. The loss of the fertile soil layer, that is, the disappearance of the vegetation that supported the soil, facilitates the action of the erosive agents (MATARREDONA, 1996).
In this way, erosion processes caused by water are significantly accelerated and suppose the deterioration of edaphic conditions in the upper parts and the damming of reservoirs in the lower levels, with the aggravating circumstance that, when most of the fires during the summer season, the forest areas are unprotected against the rains of strong intensity characteristic of the autumns (MATARREDONA, 1996).

The soil losses after each fire are remarkably important. It could be estimated that after each fire a centimeter of edaphic thickness is lost, which would need, at least, 200 to 300 years to re-form. The fire produces the combustion of the organic matter constituting the surface edaphic horizons, which has an immediate mineralization associated with it (PLATA-GUITIAN, 1966). The subsequent washing, because of the rains, also causes this delay to be lost due to runoff and erosion. As a consequence, in addition to reducing the vegetation, the conditions of rooting and germination of the plants suffer an enormous deterioration. The vegetation is forced to develop mechanisms of adaptation and defense against these conditions, so that the species are selected, while they manage to survive the fire (MATARREDONA, 1996).

Likewise, the permanence of standing dead trees and stumps predisposes to the multiplication of insects and xylophagous fungi that will constitute a potential threat to the adjoining plant mass. However, these losses also entail a change in microclimatic conditions, with marked thermal variations, less infiltration, greater evaporation and an increase in the drying action of the wind (MATARREDONA, 1996).
The fire also causes the sensitive reduction of the animal population, especially certain groups of invertebrates (gastropods, formicids, arachnids, etc.), and some small vertebrates (rodents, reptiles, etc.). On the other hand, it affects the increase in the virulence of fluvial avenues produced by high hourly rainfall, whose runoff is no longer slow to flow towards the channels; in such a way that the hillsides subjected to fires suffer serious losses of thickness and quality of soils through processes of laminar erosion or with the formation of rills, precedents, according to the lithofacies affected, of future gullies. In the same way, the sequel to the fire is manifested in a landscape in which the charred skeletons of burnt trees are the protagonists (MATARREDONA, 1996).

5.1. Effects on soil properties

Soil is the basic component of the forest ecosystem. Its sustainability and recovery depend on the chemical, physical and biological functions and processes that occur beneath the litterfall layer (NEARY, 1999; MATAIX-SOLERA and GUERRERO, 2007). After fire, the soil can suffer direct changes produced by heating and combustion, and indirect as a consequence of the microclimatic situation after the loss of vegetation cover and covering of ashes. These changes depend mainly on the temperature reached during the fire (NEARY, 1999).

Soil heating produces variations in some of the physical and chemical properties. The pH and electrical conductivity normally increase, due to the contribution of carbonates, basic cations and oxides from ashes. The recovery time of the initial pH is varied and it is considered that it is more or less fast according to the time that the ashes remain in the soil (MATAIX-SOLERA and GUERRERO, 2007). This contribution of ash also enriches the soil with an increase in nutrients (Ca, Mg, K, Na, P) and according to Kutiel and Naveh (1987) it is considered to be the greatest growth factor of vegetation in Mediterranean ecosystems.

However, there are some nutrients that are lost with the smoke of the fire, they volatilize (RAISON, 1984), or there is a danger that the action of the wind, erosion or leaching wash away this injection of fundamental nutrients, especially when there is no vegetation (ARIANAOUTSOU, 1993; NEARY, 1999; CERDÀ and BODÍ, 2007).
Nitrogen is one of the most easily volatilized elements. Large quantities can be lost during combustion, but fortunately for Mediterranean ecosystems and semi-arid regions where it is limited, it is usually found after the fire with the most available nitrogen in the soil in the form of ammonium (KUTIEL and NAVEH, 1987; GIOVANNINI, 1990; GIMENO-GARCÍA, 2000).

With regard to changes in soil organic carbon, the results are complex and varied according to the intensity of the fire. In low intensity fires there may be increases in organic carbon from partially pyrolysed vegetation, in change, at high intensities the amount of organic matter on the soil surface may decrease (MATAIX-SOLERA, 2002). According to Knoepp (2005) heating the soil at 450°C for two hours or 500°C for half an hour, 99% of the organic matter is destroyed.
But fire not only modifies the amount of organic matter, it also alters its quality. It acts as an agent that accelerates organic carbon mineralization rates and also modifies post-fire decomposition rates because, as the temperature increases, the humus undergoes modifications that make it more resistant to microbial degradation (GONZÁLEZ-VILA, 2009; KNOEPP, 2005). This carbonized organic matter, which is produced in large quantities and accumulates in the soil, can contribute 30-40% of soil carbon in ecosystems prone to forest fires and long-term carbon sequestration, being a significant component in the global carbon cycle (FORBES, 2006).

The stability of aggregates can also change after a fire. A reduction in aggregate stability related to organic matter loss is generally detected (CERDÀ, 1993; DEBANO, 1998; BADÍA Y MARTÍ, 2003). Nevertheless, it is possible to find opposite trends when there are low intensity fires in which organic matter increases (DÍAZ-FIERROS, 1987), due to clay fusions by calcination that harden the aggregates (GIOVANNINI, 1990) or even due to cementation by hydrophobic substances that make them more resistant (GIOVANNINI and LUCCHESI, 1983).

Porosity and water retention capacity can also be reduced by changing soil structure and disappearing organic matter if intensities are higher (NEARY, 1999). These three factors, together with hydrophobicity, are fundamental aspects that will determine the aeration, infiltration and erodibility of a soil, especially when vegetation and litter are removed.

Therefore, the great danger that a soil suffers in fires is degradation. When the forest is burned, the vegetation that protects the soil temporarily disappears and is exposed, for example, to the intense rains that the Valencian Community suffers in autumn, and if it plunders the unprotected soil it can produce great erosion. This is the great ecological problem, that soil is lost in very important quantities because on a human scale this is never recovered (VALLEJO, 2006).

To try to avoid the loss of burnt soil there are two things that can be done. The first is to identify within the perimeter of the fire where there is a high risk of erosion. Subsequently, it is recommended that treatments be carried out to cure the soil, such as crushing the wood itself to leave it on the ground, or putting bands with branches to stop the flow of water with the eroded soil, which allows the risk of erosion to be reduced. There is always talk of erosion risk because it depends on future predictions that are uncertain. But the key would be to make a good diagnosis and focus actions on risk areas (VALLEJO, 2006).

5.2. Effects on vegetation

The Mediterranean vegetation is naturally quite pyrophytic and has a very dry climate in summer. This means that when there is a source of ignition (natural or artificial), there is fire. And when it happens, the only thing you can do is extinguish it, or at least control it. If there is a continuous mass of pyrophyte vegetation, extinction is very difficult, not to say that in many places it is completely impossible: fire does what it wants and the means of extinction cannot stop it until it reaches a clear discontinuity (PÉREZ, 2016).

Regrowth is one of the best mechanisms of pyroresistance. Thick, low-flammable bark is developed for this purpose, which acts as thermal insulators that protect the plant so that after the fire it is capable of regrowing. In these cases, the aerial parts are burned but the stock is kept alive, which in some cases is constituted by a tissue called lignotuber that acts as a storehouse of water and nutrients to ensure the survival of the plant (MOLINAS and VERDAGUER, 1993). Quercus coccifera is the main species during the recovery of forest vegetation cover in the Mediterranean basin. This species has a great capacity to regrow

immediately after the fire and a large root system that allows in 2 or 3 years 90% of coating (SALA, 1990).
On the other hand, germinating plants adapted to fires retain seeds for a long time until they are stimulated by heat and disperse. They are serotine seeds. In these cases, the individuals do not resist the fire and are replaced by others that are born of their seeds and that find a space without competition, where much light arrives and the soil is rich in nutrients (DEBANO, 1998). Good examples are the pine cones that open with heat and disperse the pine nuts, in species such as Pinus halepensis (1786), allowing a rapid regeneration of the pine forest (ARIANOUTSOU, 1993).

In recent years, in the Community of Valencia, extinction has been prioritised over prevention; a great deal of money is being invested in extinction at the expense of prevention, and this cannot continue. Valencia has suffered decades of neglect in forest management, of the uses of mountain areas: dry corridors, livestock that for lack of profitability has practically disappeared and that there is is very poorly managed (PEREZ, 2016).

The optimum vegetation, landscape and biodiversity in the Valencia Region in the fight against fire would be a mosaic of many forms of vegetation: grazing, meadows (which have many Mediterranean species and their own), open scrub, crops and open and closed forests. The big problem that exists is the big forest fires, of many hectares, that we cannot face because they are kilometric fire fronts. A pine forest with scrub is highly valued socially, but is very diverse; on the other hand, a pasture has many more. Species as emblematic as the Iberian lynx are characteristic of the most open Mediterranean mountain, where they hunt rabbits. These are the habitats that give more diversity, not closed pine forests, which are very good because they create a lot of soil, but diversity needs many variations and changes in the territory (PÉREZ, 2016).

Mediterranean vegetation recovers very quickly. Fire is a great renewing factor: it sets everything to zero and starts again. The big pines disappear, but underneath there are many seeds and they come out again. The problem is precisely that so many grow that there is a continuous mass. It is renewing, but it leaves a desolate landscape. A fire is a great disaster as many plants, animals and insects disappear. But it regenerates. The problem is that it recovers badly and gives rise to even more flammable vegetation (PÉREZ, 2016).

5.3. Effects on *Pinus Halepensis Miller* (1786)

Pinus Halepensis miller (1786), better known as Aleppo pine, is the least robust pine of all Spanish pines and the one that reaches a more modest size, reaching 20 m in height. Its trunk is erect, often tortuous, with a greyish bark and a clear crown with little foliage. The needles appear in groups of 2, at the end of twigs tortuous, mostly devoid of leaves. They are thin, less than 1 mm thick, 6-10 cm long and light green in colour. The pineapples grow on a thick peduncle and are elongated and conical, 6-12 cm in length, with flattened scales and a little protruding navel. They are bright brown in colour and mature at the end of the summer of the second year. The pine nuts spread the following spring (DELTORO, 2008).

Figure 8. *Pinus Halepensis Miller* (1786). Author: Gregorio Ros

Their habitat is located on dry and sunny slopes, from sea level to 1000-1500m, on soils rich in lime, even in very poor and skeletal soils. Of all the Spanish pines it is the most resistant to drought, being able to withstand rainfall of around 300 litres per year in even less. Along with this pine usually grow scrub in which predominates rosemary, kermes oak, hawthorn, esparto grass and various species of aromatic plants such as thyme, cat tails or ajedreas (DELTORO, 2008).

It is a very abundant species in the Valencia Region, due to the use that has been made of it in reforestation. There are no specific threats to the Aleppo pine and its populations are out of danger. Therefore, no conservation actions have been carried out on this species as it is an abundant and endangered taxon (DELTORO, 2008).

Figure 9. *Pinus Halepensis miller* (1786). Author: on the left by Gregorio Ros and on the right is Jorge Sempere.

The distribution of the *Pinus Halepensis Miller* (1786) in the Comunitat Valenciana is continuous throughout its territory, and it is by far the most abundant tree species and the one that forms a large part of its vegetable landscapes, as can be seen in Figure 10 (DELTORO, 2008).

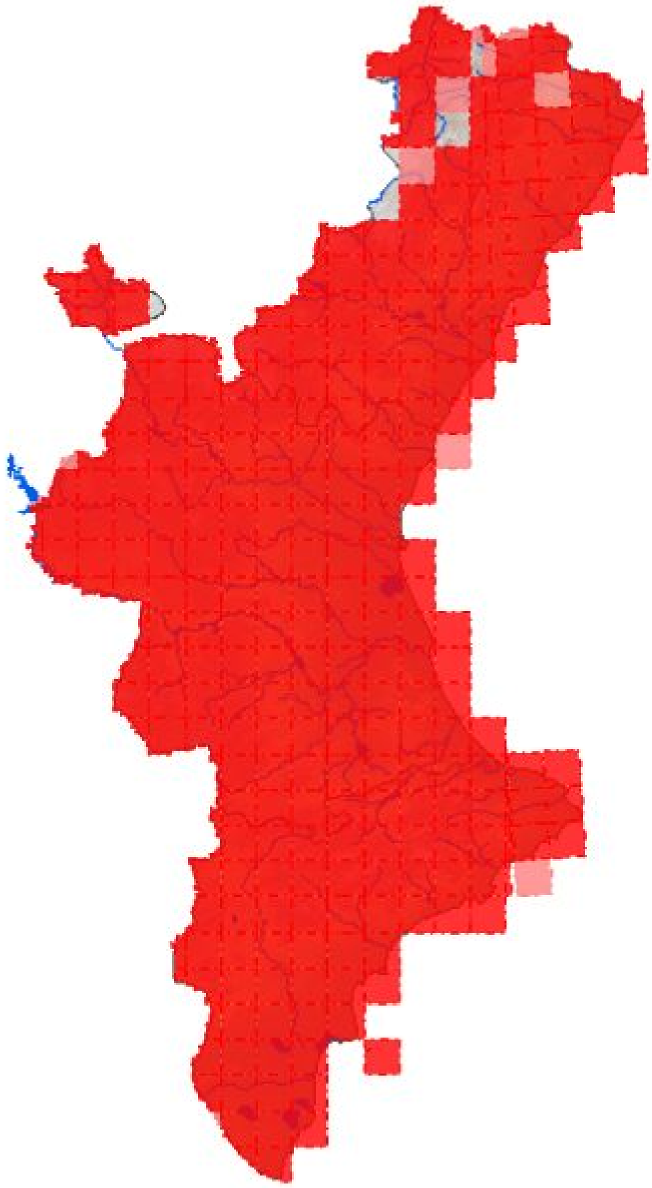

Figure 10. Distribution of Pinus Halepensis Miller (1786) in Valencian Community. Author: Vicente Deltoro Torró. Source: Ministry of the Environment, Water, Urban Planning and Housing (observation period: 1915 - 2019)

In the Figure 10 we can see the distribution and abundance of Aleppo pine in the form of red squares and roses.
It should be made clear that pine forests, whether due to the degradation of climatic vegetation or to excessive reforestation, should not be considered as forests, but as wooded formations that are far from being the final stage of an evolutionary dynamism, especially in the thermo and mesomediterranean floors (COSTA, 1986).

Pinus Halepensis Miller (1786), like the other pines, die and do not recover. But they stay: the important thing is the offspring. The world of the pirophytes is perverse. If we maintain them, their dynamic will be: fire, fire, fire and fire. All that will be needed is recklessness, the delinquent or the lightning. This type of pyrophytic vegetation does well to ignite and benefits from the available space and the mineral salts of the ashes. They enter a vicious circle that we have to break by opening the vegetation and trying to displace these plants by others that little by little give scrub or open forests (PÉREZ, 2016).

6. Prevention of forest fires

In the prevention of forest fires, only biological factors are susceptible to be modified by man, hence, bringing vegetation closer to the "climax", the incidence of fire will be lower (repopulation of Quercus, for example), while repopulation policies with pyrophytic species (pines) or in topographically and climatically inadequate places, will increase the risk. Therefore, native species should be considered in such reforestation, as they generate less weeds and have less fuel. Likewise, the reforestation activity should be integrated with other sectoral policies and the importance of hydrological policy should be considered (MATARREDONA, 1996).

And speaking of policies, it is necessary to make a change in forestry policy, which goes through a legislative review aimed at adapting the law to the current circumstances of the mountain, especially to the valuation of ecological heritage and to promote defense in privately owned forests. In addition, greater vigilance and harsher sanctions should be implemented for those responsible (MATARREDONA, 1996).

Due to the abandonment of exploitations and of the traditional uses of the soil, logical cleaning tasks must be carried out, since there is an unstable biomass in the forest lands that increases the risks of fire. This cleaning must contribute to the disappearance of dead vegetable residues accumulated in the soil, which are the same ones that form the unstable biomass previously mentioned.

Another preventive measure could be the professionalization of the extinction brigades, providing them with better equipment and a good technical and physical preparation. In the area of surveillance and extension, the speed at which the fire is stopped must be reduced and transport capacity increased, which has been considerably improved in recent years through the use of helicopters (MATARREDONA, 1996).

Awareness of this great problem that affects us all is very important. For this same reason, to impart informative and formative processes that make possible the acquisition of a social conscience on the irreparable consequences of the forest fires, would be of vital importance (MATARREDONA, 1996).

6.1. SIDEINFO®

SIDEINFO® (Forest Fire Defence System), is a system designed in Valencia (Spain) to provide the villages located in forest lands with a defensive structure in the event of an incident related to fire (SIDEINFO®).
This system is based on the combination of 4 fundamental pillars: planning, forestry, training and formation. For this reason, it won the international prize for best practices (SIDEINFO®).

The planning includes self-protection plans, forest fire prevention plans and emergency plans. On the other hand, forestry is based on firebreaks associated with roads, design and management of interior gardening, perimeter bands, cleaning of interior plots and pyrogardening. And the training is based on training programmes, simulations and practical exercises, and finally on extinguishing equipment and tools (SIDEINFO®).

With regard to the infrastructures used, we distinguish three applicable systems: Domestic, Collective and Portable/Sappers (SIDEINFO®).

Figure 11. Infrastructures offered by the company SIDEINFO® to fight forest fires. Source: official website of SIDEINFO®.

6.1.1. Household system of SIDEINFO®

The domestic system is used when it comes to protecting a single building such as housing, farm school, nature classroom, etc. (SIDEINFO®).

The design involves the installation on the roof and on the façade of a series of diffusers that project water onto the structure and surrounding vegetation generating a "bubble" of self-protection against a possible forest fire (SIDEINFO®).

The benefits that the system provides to the dwelling are multiple: it diminishes the risk of propagation inside the dwelling; it has a remote activation of the system from a mobile device; it adapts the garden with species more resistant to the passage of the fire; it does not require specialised personnel, it can be activated by any person; there is a connection to a central alarm receiver; and it consists of energy autonomy (SIDEINFO®).

Figure 12. Portable applied to the domestic defense by the company SIDEINFO®. Source: official website of SIDEINFO®.

6.1.2. Collective system of SIDEINFO®

The collective system is used to protect housing estates, groups of houses or an environment as a whole: camping, warehouses, industries, etc. (SIDEINFO®).

It acts by dampening the vegetation with artificial rain before the fire is near, creating conditions in which the fire cannot spread towards the village, thus reducing its danger and the seriousness of its consequences (SIDEINFO®).

The benefits that the system provides to the housing are multiple: it reduces the risk of propagation inside the urbanization; it can be activated remotely from a mobile device; it creates a design of perimeter firebreak areas to the urbanization; it does not require specialized personnel, being able to be activated by the same personnel of maintenance of the urbanization; there is a connection to a central receiver of alarms; it improves the conditions of confinement; and it consists of energetic autonomy (SIDEINFO®).

Figure 13. Simulation of the operation of the SIDEINFO® Collective for the prevention of forest fires. Source: official website of SIDEINFO®.

Figure 14. On the left is a column of lattice-type emission and on the right a column of braced emission, both created by the company SIDEINFO® for the prevention of forest fires. Source: official website of SIDEINFO®.

6.1.3. Portable/Sappers system of SIDEINFO®

The Portable/Sappers system offered by the company SIDEINFO® is designed for use by Fire Consortia, Military Emergency Unit, Civil Protection or when there is no permanent Collective Defense system, or domestic system support (SIDEINFO®).

The benefits that the system provides to the dwelling are multiple: thermal reduction on the structure and vegetation; reduction of the radiant screen; reduction of the risk of propagation; rapid and temporary installation of a defence line; it does not need the permanent presence of extinguishing personnel; security and effectiveness of extinguishing means; greater defence perimeter with less extinguishing personnel; reduction of means necessary for the defence; capacity to mobilise water from any tank, swimming pool or hydrant; and great flexibility (SIDEINFO®).

The place of installation can be half a slope, supported by road, in the perimeter of the population center or as support to the Domestic SIDEINFO® (SIDEINFO®).

The characteristics of this system consist of an approximate range of 25 to 45 metres; an optimum working pressure of 2.5 to 4 kg/cm²; a turning capacity of 360º; an average full turning time of 40 seconds; a protected area of 1,900 to 6,400 m² per unit; a connection to fire hydrant, swimming pool, tank, fire pump and/or motor pump; and a possibility of use with FIREADE 2000 ®, which is a retardant and moisturising additive (SIDEINFO®).

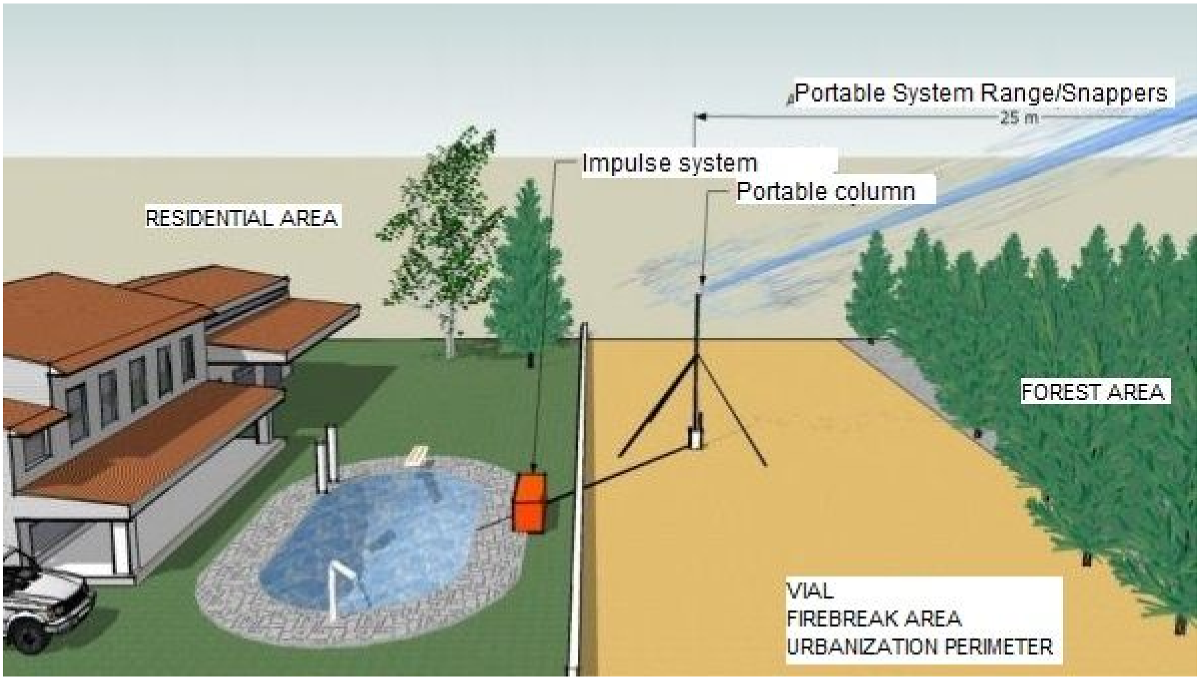

Figure 15. 3D simulation SIDEINFO® Portable/Sappers supported in road and/or perimeter of the urban nucleus. Source: official website of SIDEINFO®.

7. Conclusion

The Valencian Community has a Mediterranean climate favourable to the spread of fire, as demonstrated by the adaptations that have been suffered throughout the evolution of plant formations. However, the capacity for recovery has changed in recent centuries due to the abuse of the cultural use of fire and human activities on ecosystems, becoming the Spanish region that has suffered the highest proportion of mega fires since there are direct records, and probably in Europe (GENERALITAT VALENCIANA, 2017).

Currently, the extremes generated by the phenomenon of Climate Change are becoming a critical factor. In recent decades, more frequent heat waves have occurred, with days when the probability of ignition is higher and the behaviour of forest fires is typically more extreme and may exceed extinction capacity (CARDIL, 2013).

Therefore, it is of vital importance to act now, because there are larger and much more frequent fires. And not only will they affect ecosystems and produce large irreparable effects, but they will move closer to urban areas and people will realize that it is too late to act.

Preventive measures and, above all, awareness-raising are necessary, and I see a need to communicate directly to people, to talk more about it and to invest more money in it.

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