Use of fire as a tool for habitat management and fire risk reduction

LIFE MONTSERRAT (2014-2019)

bombers

Index

Report

1. Introduction

This report gathers the accumulated knowledge and lessons learned using the fire as a tool for the Site of Community Importance (SCI) management and the risk of large forest fires. The use of prescribed burns is coming more widespread in the countries that make up the EU but it is rarely used searching at the same time all the objectives set out in Life Montserrat and specifically in habitats of a markedly Mediterranean nature, as is the case with the Montserrat Mountain.

2. Role of fire in habitat management

In the current framework, habitat conservation cannot be conceived without taking into account the role of fire. Understanding fire as a natural process inherent to Mediterranean ecosystems requires the integration of its presence and effects in any planning process.

Limiting the scope of large forest fires involves developing a strategy aimed at limiting/containing the potential size of these fires, and also another one aimed at reducing the vulnerability of current landscapes to develop extreme fire behaviors that can condition the viability of current habitats.

In this framework it becomes relevant to go in depth into our knowledge of the relationship between fire and species, populations, habitats and the natural disturbance regime that links them.

From 1998 the *Bombers de la Generalitat de Catalunya* has been using fire as a management tool by means of the implementation of prescribed burns, with the aim to preserve the resilient capacity of habitats, the creation of strategic areas suitable for the confinement of large fires and with the objective settle a dosage over the values of biomass ready to burn in case of fire.

Human activity over the past 80 years has altered natural and other ancient anthropogenic processes that had evolved and coexisted with habitats of community interest. Those areas where the degree of alteration of processes has been greater are also more vulnerable to large forest fires. For this reason it is considered that recovering the use of fire as a natural process will increase the possibilities of persistence of the habitats of community interest.

3. Purpose of the prescribed burns

The use of fire in the forest parcels at Life Montserrat had three main objectives:

- Reducing the load of biomass available for burning in order to reduce the intensity of the fire front in the event of a fire.
- Re-invigorate the species of greatest shepherding interest
- Recovering open spaces for the improvement of habitats of key species


Figure 1. The images above have the aim to show the effects of fire in a forest parcel in which prescribed burn has been applied. The image on the left shows the situation previous to the prescribed burn and the image on the right shows the situation 6 months after the burn. The scrubland coverage is reduced and the grass layer rejuvenates. The load of vegetal fuel available lowers and the distance between the tree canopy and the floor increases.

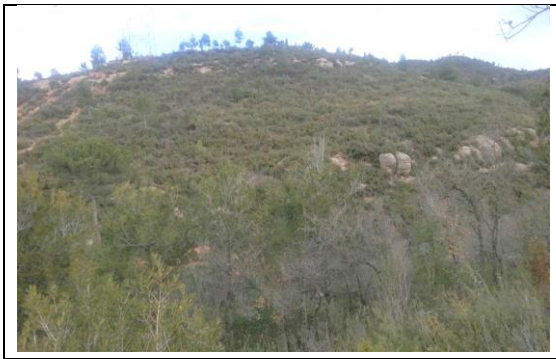



Figure 2. The left image above shows the situation previous to the prescribed burned in where a continuous scrubland coverage is dominant. In the image on the right it can be observed the situation 3 months after the prescribed burn. The scrubland coverage has been dramatically reduced with the aim to favour nesting and hunting spaces for *Oenanthe leucura*.

4. Planning of prescribed burns areas

The location and planning of the areas to burn were carried taking into account two main premises:

- The prescribed burn had to be included in some strategic area of control and confinement of large forest fires identified by the *Bombers de la Generalitat*.
- Prescribed burns had to be done to maintain or recover open spaces, preferably scrublands or areas with a low density tree coverage. Thorough the project and with the development of the planning process, it was observed that to give more sense to the treated zones it was preferable to group areas of treatment together, even if they included forest areas with higher tree cover.

5. Prescribed burns implementation

5.1. General data

Burns were carried out in 5 priority management units (PMUs) over a total of 65 ha. Thirty days were used to carry out the burns with teams with complete ignition and control equipment, about 90 days for control standby teams (hot spot control) and about 20 days for plot preparation (tasks of pre-burn work). A total of 175 people with different functions and dedication have participated in the process.

The table below shows the prescribed burning areas planned and carried out by PMUs and done by year during the project, as well as the number of burning days used for each year.

Table 1. Burning data by Shepherding Management Units (PMU) and year

Nº PMU	PMU Name	Area of planned prescribed burns (ha)*	Area of prescribed burns executed (ha)	2015 (ha)	2016 (ha)	2017 (ha)	2018 (ha)	2019 (ha)
4	*Obaga de les Elies*	18,3	17,0	-	-	5,9	11,1	-
5	*Can Maçana-La Guàrdia*	6,3	5,7	-	-	-	-	5,7
7	*El Gall*	10,6	6,5	-	-	-	-	6,5
9	*Serra del Rubió-Gatell*	19	15,9	-	-	15,9	-	-
10	*El Mimó-Puigventós*	33,7	20,1	1,3	14	4,8	-	-
TOTAL (ha)		**87,9**	**65,0**	**1,3**	**14**	**26,5**	**11,1**	**12,2**
TOTAL (days of prescribed burns)	**30**			**1**	**5**	**10**	**7**	**7**

* *Area considered in the technical documents of the burning plan.*

5.2. Characterization of prescribed burns plots

5.2.1. Location and orography

The mountain of Montserrat and its surroundings have a rather abrupt topography characterized by steep ravines (>50%) and significant slopes (200 to 600 m). This type of orography complicates fire safety, since the possibility that a fire could scape makes control work very difficult, increasing the potential for transformation a prescribed burn into fire.

Figure 3. Orographic position of the Can Rubió prescribed burn plot >45% average slope and a difference in level of 200 m. The slope on which the plot is located has a continuity of > 1 km and an escape to the opposite slope could be a fire potential of more than 400 ha in the Montserrat Mountain.

5.2.2. Plant structures

The plant structures on which the prescribed fire was applied were varied, characterized mainly by the presence of *Pinus halepensis* and *Pinus nigra* as tree and shrub species typical of Mediterranean *maquia* (shrubbery) conformations.

Figure 4. Open areas with dispersed regenerated *Pinus halepensis* from the 1994 fire.

Figure 5. Continuous regenerated *Pinus halepensis* from the 1986 fire that has been treated with clearing without the removal of remains.

Figure 6. Scattered adult mass of *Pinus halepensis* affected by the 1986 fire with brush subfloor.

Figure 7. Scattered adult mass of *Pinus nigra* affected by the 1986 fire with brush subfloor

Figure 8. Adult mass of *Pinus halepensis* with subfloor of quercines and bushes

5.2.3. Dynamics of the prescribed burns

The prescribed burns are carried out in accordance with a previously designed and approved burning plan, which clearly specifies the prescription window, i.e., the weather conditions, topographical and fuel conditions that must be accomplished in order to achieve the objectives established by the prescribed burn in a safe and controlled manner. The burning plan specifies the objectives of the burning, the prescription meteorological window, the preliminary work for conditioning the area, the resources required and the characteristics of the ignition, among other things. It is essential that specialized personnel plant and execute the prescribed burn. The preparatory work consists of the execution of the delimitation or anchorage lines to limit and sub-parcel the prescribed burning plot in a physical line.

Figure 9. The image shows the line of defence executed in works done previously to the prescribed burn and also the control team with water line during the burn

The ignition pattern is used to drive the burn, which must be adjusted to the objectives and safety of the prescribed burn taking into account the weather, the slope and the fuel load. Likewise, the ignition pattern can adjust the intensity of the front (length of flame) by varying the run space (stroke space) by applying the fire linearly or isolated, or by modifying the interaction between fronts, in order to adjust the optimal fire behaviour and thus achieve the objectives described in the burning plan.

Once the ignition phase of the fire is completed, the mop-up or standby crew phase is carried out, which consists of cooling the hot points and sealing the perimeter to ensure that the fire does not exceed the established limits.

Figure 10. Firefighter of the ignition team applying a pattern of head-burning using a continuous ignition line. The ignition pattern is adjusted and adapted according to the fire behaviour and the desired targets.

In the case of the burns carried out at Life Montserrat, the main characteristics in each of the areas of work were as follows:

Safety and control: due to the potential that the fire could escape from the burning, the control crew had to be powerful to ensure safety. It involved dimensioning the lines of defence and providing the water lines that protected against possible fire jumps with enough personnel.

Ignition team: complex terrain and either complex plant structures did required qualified and well-dimensioned ignition crews able to cope with changing patterns and with full working days with ongoing fire.

Previous Works: in most of the cases the limits of the burns had to be carried out by means of the creation of lines of defence executed *exprofeso*, with manual tools or strimmer (brushcutters) given the few opportunities that the land gave to be able to mechanize the works.

5.2.4. Prescription windows

The weather parameters that make up the prescription windows can be separated into two different periods throughout the year:

- Winter prescribed burns;
  - Anticyclonic situation
  - Tº < 15º C the major part of the days
  - HR variable (2019 HR<30% the major part of the days)
  - Stable and light wind
- Summer prescribed burns;
  - Variable situations
  - Tª > 24º C, Max. of 30º C
  - HR variable and highly evolutionary >35%
  - Light winds and changing and moderates winds

The value of drought has special relevance in the impact and severity of the prescribed burns both in the vegetation alive and in the upper soil mulch. In this sense, different periods of drought have alternatively appeared: periods of severe drought near the percentile 90, with other periods 2018 and 2019 more close to normal values wit percentiles of 50.

6. Prescribed burns statistics

6.1. Distribution of area available for burns by year

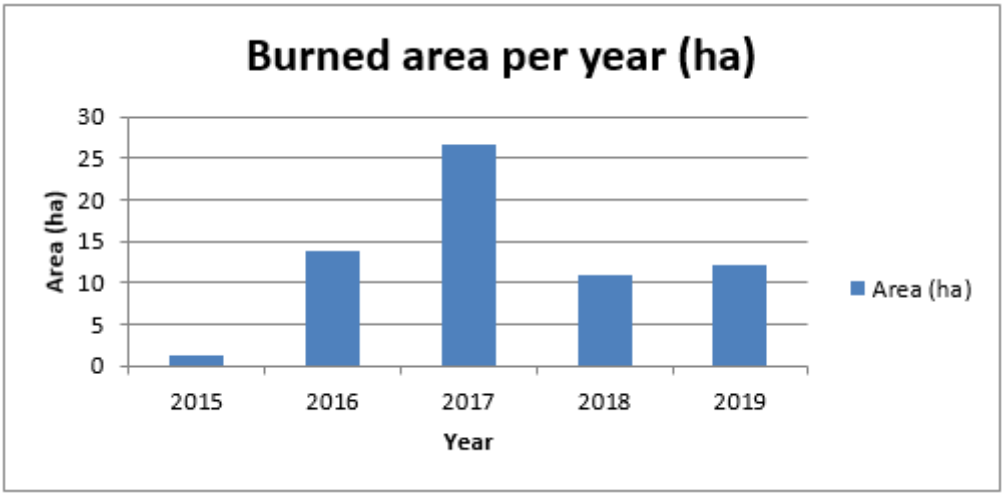


Figure 11. Distribution of burnt area per year.

The distribution of burned area each year is based on a number of reasons explained next:

- **2015**. Mainly dedicated to the determination of strategic areas and the search for plots suitable for burning.
- **2016**. Dedicated to establishing agreements with the owners of the properties to be burned and initiating the dynamics of planned burning
- **2017**. Best year for burning limited in part by severe late summer drought conditions
- **2018**. Winter period characterized by continuous rain and few optimal weather windows. The summer period was marked by the problem of access to the burning plots, unfeasible roads for the pumps.
- **2019**. The year in which the project was closed so it only allowed to take advantage of the winter period.

6.2. Distribution of average area burned per year

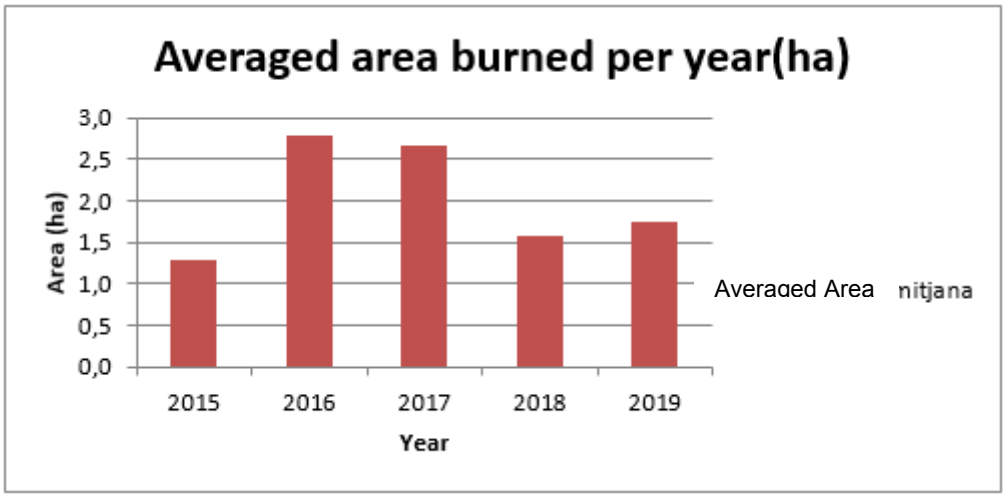


Figure 12. Distribution of average of burned area plot per year.

The average earn estimated in the initial proposal was 7 ha/day of burning based on existing references from experience in this type of prescribed burns, and which corresponded to the beginning of the project observed in open spaces in the Pyrenees. The implementation of the burns in the area of Montserrat, taking into account the conditioning factors of the orography and the complexity of the plant structures, did not allow the average of 2,5 ha/day to be exceeded. In the case of 2019, known by being the driest and hottest winter in recent decades, the windows of prescription were too tight to allow to apply ignition patterns at a normal rate, thus obtaining surface area burned earns below the average of previous years.

6.3. Distribution by structure of vegetation burned.

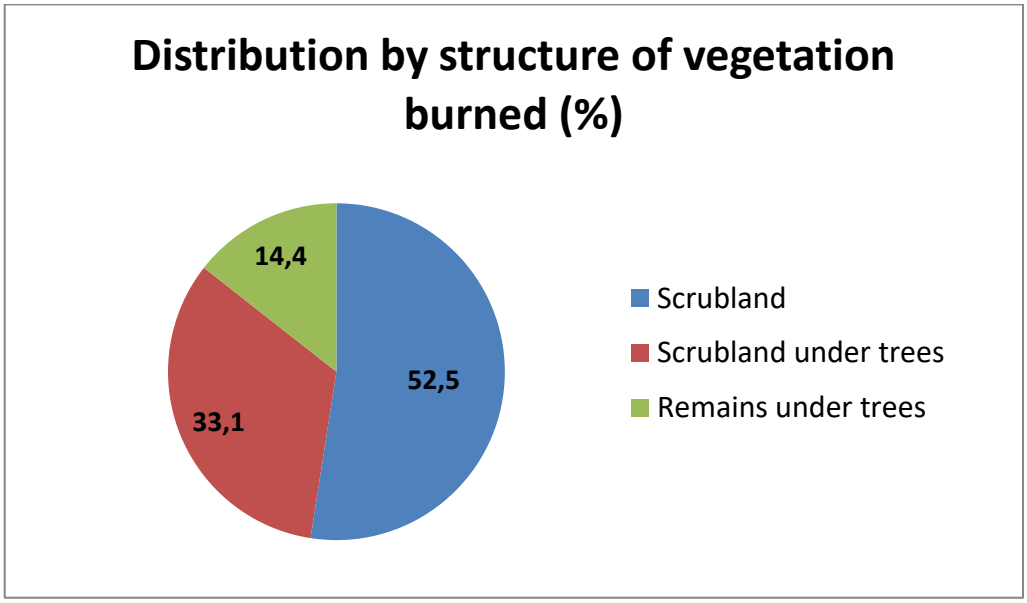


Figure 13. Distribution of burned area according to vegetation structure.

Although the initial objective was to maintain and recover open spaces with low tree cover, in reality the proportion of this type of space in strategic areas with good grazing characteristics was lower than expected. Finally, it was decided to alternate the burning of wooded and open spaces with good grazing skills and consolidated herds.

6.4. Distribution of burned area by month

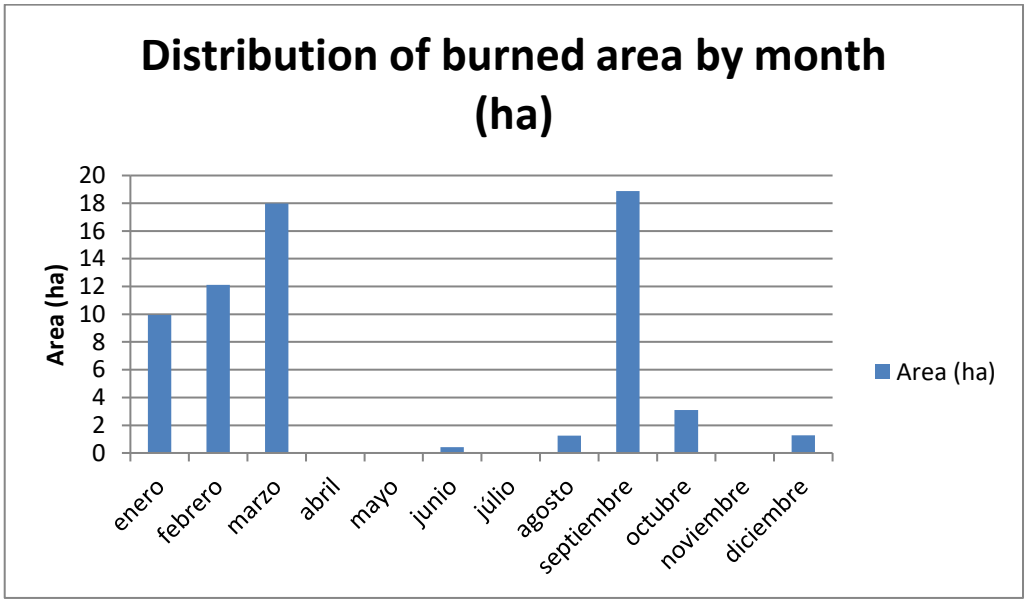


Figure 14. Distribution of burned area by month (ha).

The figure 14 about the distribution of burns throughout the year shows the two main periods of activity in which the conditions are ideal for burning. The winter period coincides with the vegetative stop that allows the burning to take place thanks to the availability of the herbaceous stratum, which is kept dry due to the low physiological activity. This implies that can therefore burn under conditions of low environmental temperature and with limited effect on the tree stratum (January, February and March).

A stop is established in the spring season that coincides with the reproductive activity of animal species and the hydration of the herbaceous stratum that does not allow make burns so easily (plant tissues with high water content).

This period lasts until the first half of summer, which usually happens together with the highest risk of forest fires, when burning is discouraged because of the high risk of escape presented by the fires, in addition to the high severity that could be for forest structures.

At the end of the summer, occurring simultaneously with the decrease in the level of fire risk, the second most important burning period begins, which coincides with the availability of herbaceous fuel and the controlled severity. From mid-October onwards, the reduction in daylight hours allows few hours of fire activity per burning day, thus the mobilisation of resources becomes unprofitable.

7. Impact assessment

The use of fire in habitat management requires knowledge and assessment of the effects that it will cause in the short and medium term on the populations and species in this habitat. The intensity of the fire and the time of year in which the burning takes place are two of the most relevant aspects to evaluate the effect of prescribed burns.

The intensity of the fire determines the number of layers affected (herbaceous, shrub and tree), the greater the intensity more layers and more severity, and the degree to which the organic mulch in the top layer of the soil is affected.

The time of year is linked to the response capacity of the plant species that are in the habitat according to their vital strategies of persistence (dissemination, regrowth or combined), which will favour or harm different groups. Summer burns generally favour the group of plant disseminators and winter burns favour the re-sprouting species. This will configure different populations in the medium term depending on when the prescribed fire is applied. It is considered that summer burns favour the implantation of grasses that form the herbaceous stratum and, on the contrary, winter burns favour the re-sprouting bushes group, which is more common in the Mediterranean *maquia* (shrubbery).

If we analyse the resulting effect considering the forest conformations treated at Life Montserrat, the following results are obtained:

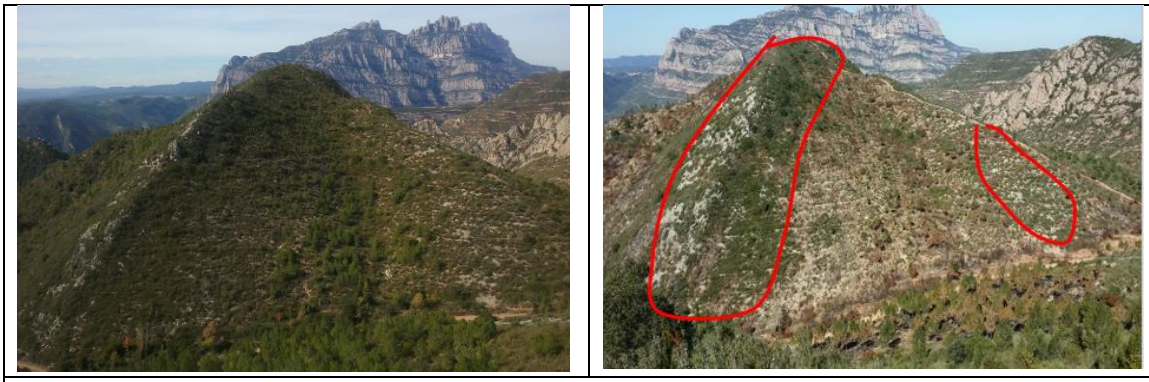


Figure 15. In areas of open scrub on rocky soil and with hardly any herbaceous stratum it is difficult to achieve the removal of the shrub stratum in winter burns due to the absence of fine fuel to run the burn. The left image shows the situation before the burning and the right one after it. It can be seen (red circles) how in the most rocky areas the vegetation has hardly been impacted.

Figure 16. The sequence of photos shows the short and medium term effects of prescribed open space burning. The absence of a sufficient amount of livestock in the first 3 years allows the bushes to reoccupy the space clearly. The density and load of biomass does not reach the values of the pre-burning situation, but clearly indicates the evolution of the plot in the medium term.

Figure 17. The bush burns carried out in summer areas with slopes exposed towards south and under marked drought conditions have generated a greater impact, influencing the covering capacity of the main species. These burns were applied in those spaces with the aim to expose the soil to favour the nesting and predation of *Oenanthe leucura*. The degree of exposure of the soil in these cases is high.

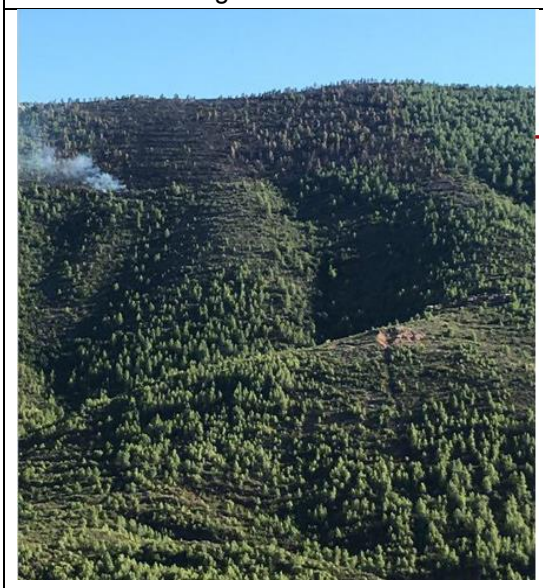


Figure 18. The bush burns carried out in summer in areas with slopes exposed towards north, show high initial severity but the following coverage of the herbaceous stratum is bigger in the medium term, improving the shepherding quality of the treated plot.

Figure 19. The effect of the burns on the mature stands of *Pinus nigra* was very positive since it was possible to eliminate the lower shrub layer accumulated since the 1986 fire doing it with a minimal effect on the canopy. The resulting structure shows a low vulnerability to crown burning and allows for the evolution towards more advanced stages of habitat maturity, reducing the threat of the effects of a possible fire.

Figure 20. Burns regenerated *Pinus halepensis* masses treated by clearing without the removal of remains show a high severity, with significant crown damage and high mortality. The presence of remains even 8 years after the clearing generates sufficient intensity to impact the tree crowns, even when burning when it is make in weather windows with low temperatures and very conservative ignition patterns.

8. Cost analysis

8.1. General Data

The total number of hours spent on prescribed burns is approximately 5.700 h with a total cost of 146.000 euros, which when applied to 65 hectares treated by prescribed burns is equivalent to an average cost per hectare of 2250 euros.

The burns were carried out by *Cos de Bombers*' own personnel organized in teams with different functions; planning, preparation, burning and subsequent lookout standby crew. A total of 175 people participated with different functions and categories.

The total number of hours spent on burning also includes those days when incidents occurred at the access points, which left fire engines blocked due to the poor state of conservation of the access roads to the burning plots. This occurred in two days and affected entire burning teams who had to spend much of the day rescuing vehicles stranded in the mud.

The rest of the days dedicated to burning were fully used but bearing in mind that daily efficiency depended a lot on weather conditions and fire behaviour. This is why, in the use of fire as a management tool, it is so important to correctly adjust the weather forecast and to make the most of the work of the burning teams.

Various cost statistics are analysed below.

8.2. Distribution of hours spend on each action.

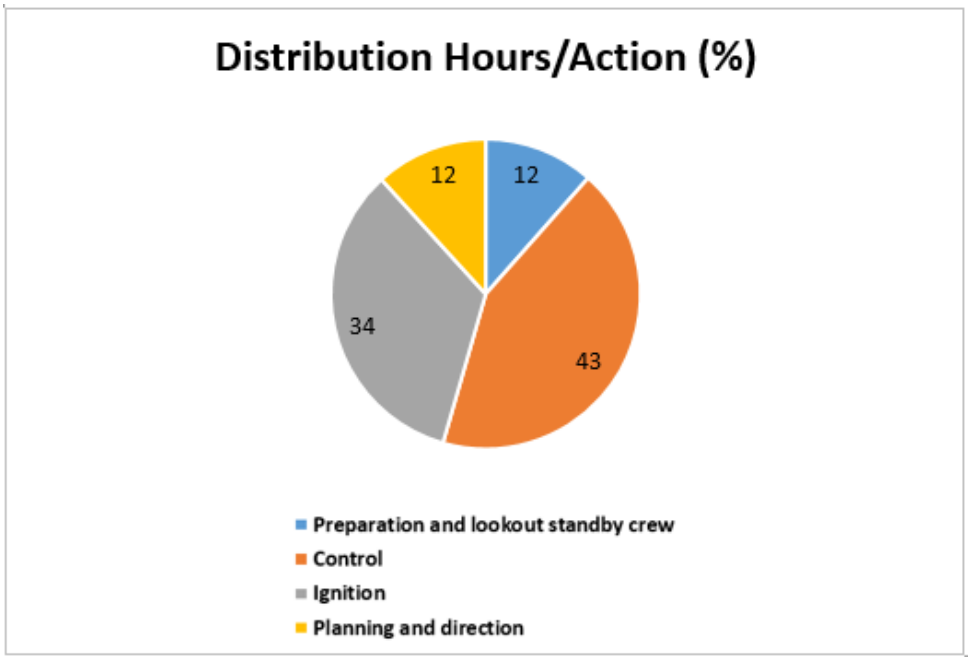


Figure 21. Distribution of work hours considering each type of action.

The fact that more than 40% of the time was spent on the function of burn control indicates that the investment of resources in safety to prevent the escape of burns was high. As previously mentioned, the prescribed burns were placed in locations with high potential for fire escape (orographic complexity) and a significant part of them were carried out during the summer season with weather conditions considered limit to guarantee fire control.

8.3. Distribution of costs per action

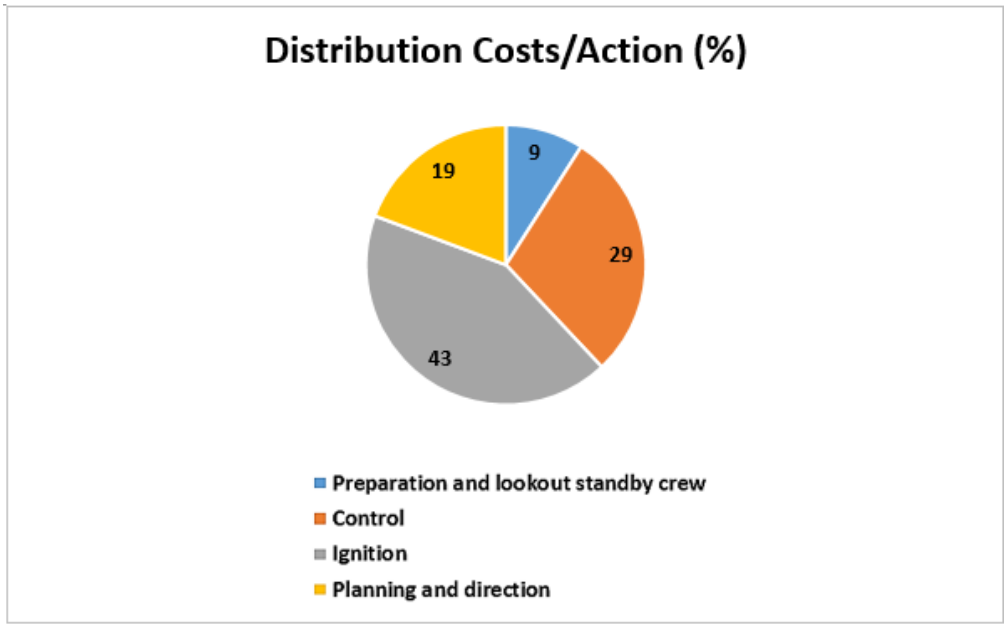


Figure 22. Distribution of costs per type of action.

The distribution of costs per action responds to the logic of the professional category assigned to each action, with personnel dedicated to planning and management being the highest category, followed by the most specialized personnel assigned to ignition

equipment, and finally control and lookout standby crew personnel representing lower category requirements.

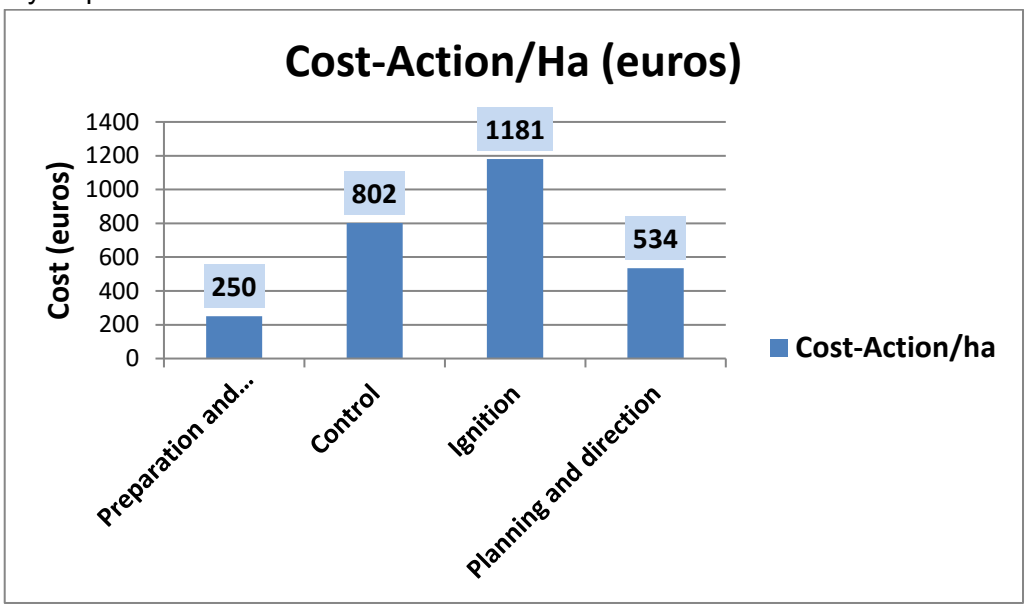


Figure 23. Distribution of costs per type of action and per area.

In the graph above it is depicted the weight of each action assigned to each hectare of burning. In this case, we can also see how the actions related to higher labour categories, such as planning and management, and those of the ignition teams have a greater cost per area.

In the specific case of the Life Montserrat prescribed burns, the dedication to planning and management was greater than the *Bombers'* normal pattern in the development of its usual prescribed burns program. This was due to the extra efforts made by the technical staff in searching for appropriate locations for burning plots, managing agreements with private owners, processing administrative permits and directing burns in general, which required extra dedication and supervision.

It is also worth considering that the costs/hours by labour categories of the *Cos de Bombers* are higher than the standards of labour qualification required to carry out the control and ignition tasks. This is because they are accomplished by qualified personnel that are able to respond to any type of emergency whom have specific training and labour professional certification higher than those required to be a qualified forestry worker. This element is important to consider whether a comparative study of costs between different types of forestry treatments (such as manual and mechanical clearing) is to be carried out.

8.4. Distribution of costs by year and area

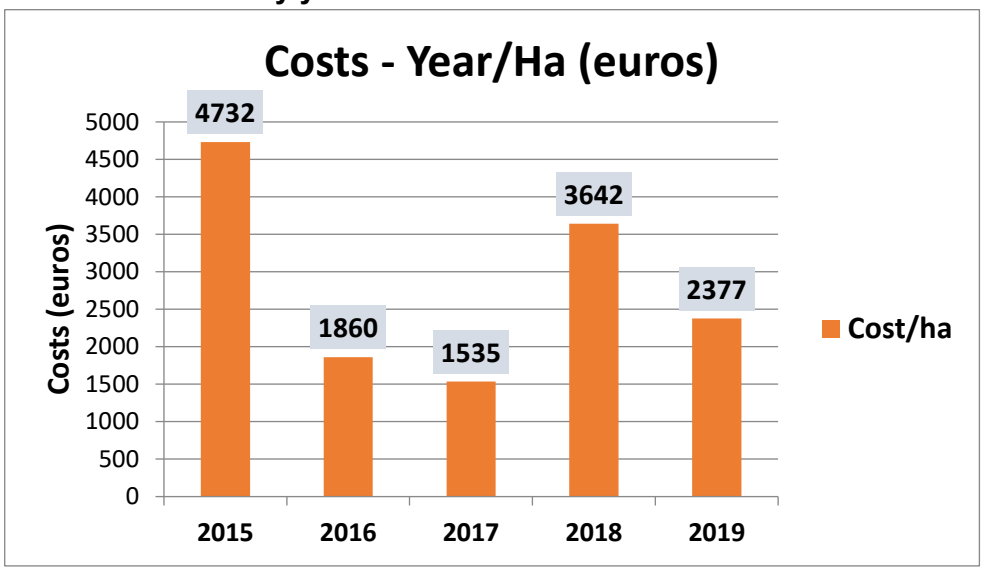


Figure 24. Distribution of annual costs by burned area.

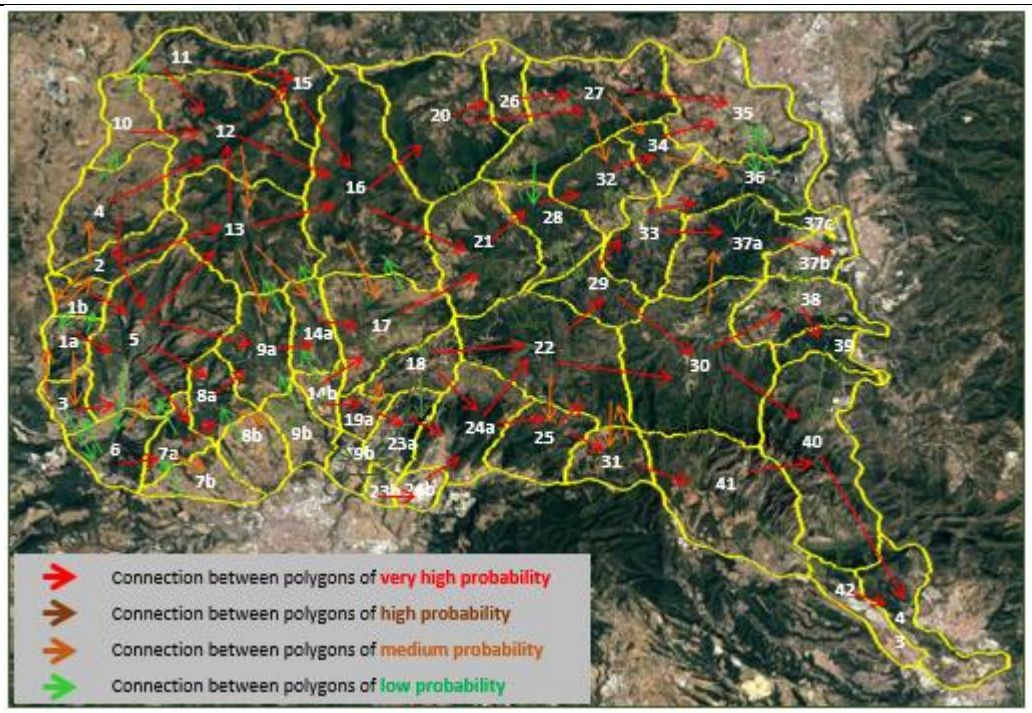
The analysis of the Figure 24 allows to appreciate that the costs per hectare in the first year (2015) are much higher than the rest, mainly due to the high number of hours spent on planning the plots compared to the amount of hours carried out in burning.

The years with higher burned areas (2016 and 2017) show costs lower than 2000 euros/ha, due to the larger size of the burning plots used and also to the good weather conditions. However 2018 and 2019 years entail greater problems due to the complexity of the structures to be burned and the situation of having the weather windows in their limits.

8.5. Cost-efficiency analysis of prescribed burn treatments

As explained in section 3 of this document, the location of the burning plots meets the demand of the selection of strategic areas for the confinement of large forest fires. The selection of the strategic areas was based on the analysis of forest fires carried out by *Bombers* in the geographical area of Life Montserrat. Those ended up being the areas where Life actions would be implemented under the name of Priority Management Units (PMU).

The analysis for the selection of strategic areas is carried out based on historical fires, patterns of propagation by type fires, polygons of potential and the probability of connection between polygons.



Polygons of potentials and connections

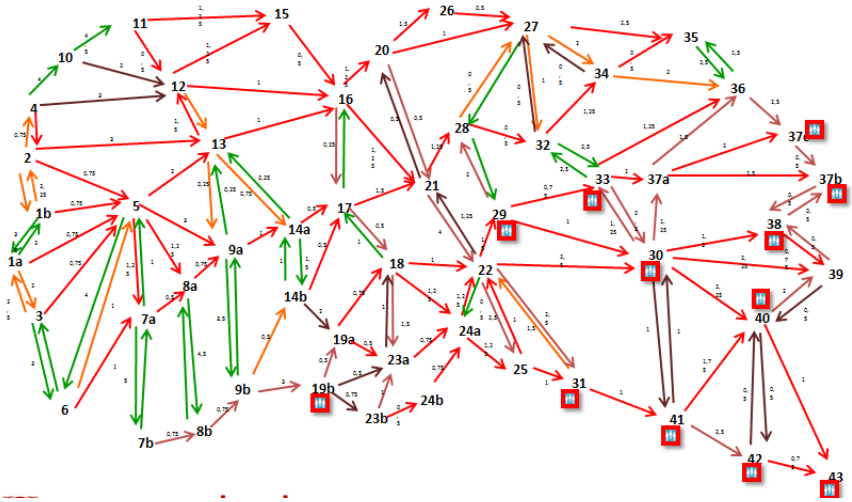


Figure 25. The first image above shows the polygons of potential of the Rubió-Montserrat mountain range and the probability of connection between polygons based on propagation patterns and extinction capacity. The second image above shows the scheme of connections in which potential scenarios are analysed and extinction system strategies are established based on the values assigned to each polygon; surface area, impact on people, properties (real estate), infrastructure; ecological, heritage and cultural values, etc.

Firefighting strategies are focused to face the most adverse potential scenarios, establishing which connections between polygons need to be deactivated in order to minimize the impact of large fires.

The deactivation of key connections, has the implication on the ground of the identification of strategic areas (PMUs), which are reflected into the actions included in the Life project, including the prescribed burns.

The cost-efficiency analysis (CEA) is widely exposed in the study carried out within Life Montserrat (action D4.1 ACE Life Montserrat Report) by the Centre for Forest Science and Technology of Catalonia. The study establishes the appropriate CEA indexes to use for the actions carried out in the PMUs.

As stated in the conclusions section of the mentioned study, even with average investment values of more than 1.300 euros/ha, the actions carried out in the PMUs aimed at reducing the biomass load and improving grazing enhance the extinguishing capacity in the strategic areas identified by *Bombers*, clearly reducing the potential for fires. The cost-efficiency balance is positive and justifies the investments made.

9. Lessons learned

9.1. Scope of planning

- Planning prescribed burns in spaces with softer topography allows to reduce the danger of fire escape and to improve the outputs.
- Planning larger burn spaces simplifies management efforts and reduces costs.
- Starting from planning that includes a variety of structures to be treated in different locations allows for better use of prescription windows.

9.2. Fire as a tool for habitat management and improvement

- The use of prescribed burns for the maintenance of adult tree structures with an herbaceous stratum for grazing seems to be an interesting and easy to execute option, both in populations of *Pinus halepensis* and *Pinus nigra*.
- The use of fire in regenerated *Pinus halepensis* treated with clearing without elimination of remains generates high mortality rates even 8 years after the treatment.
- The use of fire for the recovery of open spaces in bush structures on land not much suitable for other traditional means, due to slope limitations or owing to stony conditions, is an interesting and viable option. It must be taken into account and evaluated the impact of fire on this type of land, which is exposed to the danger of erosion, and weighed this against the improvement of habitat for species of high ecological interest. In any case, they have been of a restricted nature and on plots of < 4 ha.
- The effectiveness of the fire effect improves in the medium term with the immediate subsequent entry of livestock to the burned plot, managing to inhibit the regrowth of shrub species and improving the composition of palatable species.