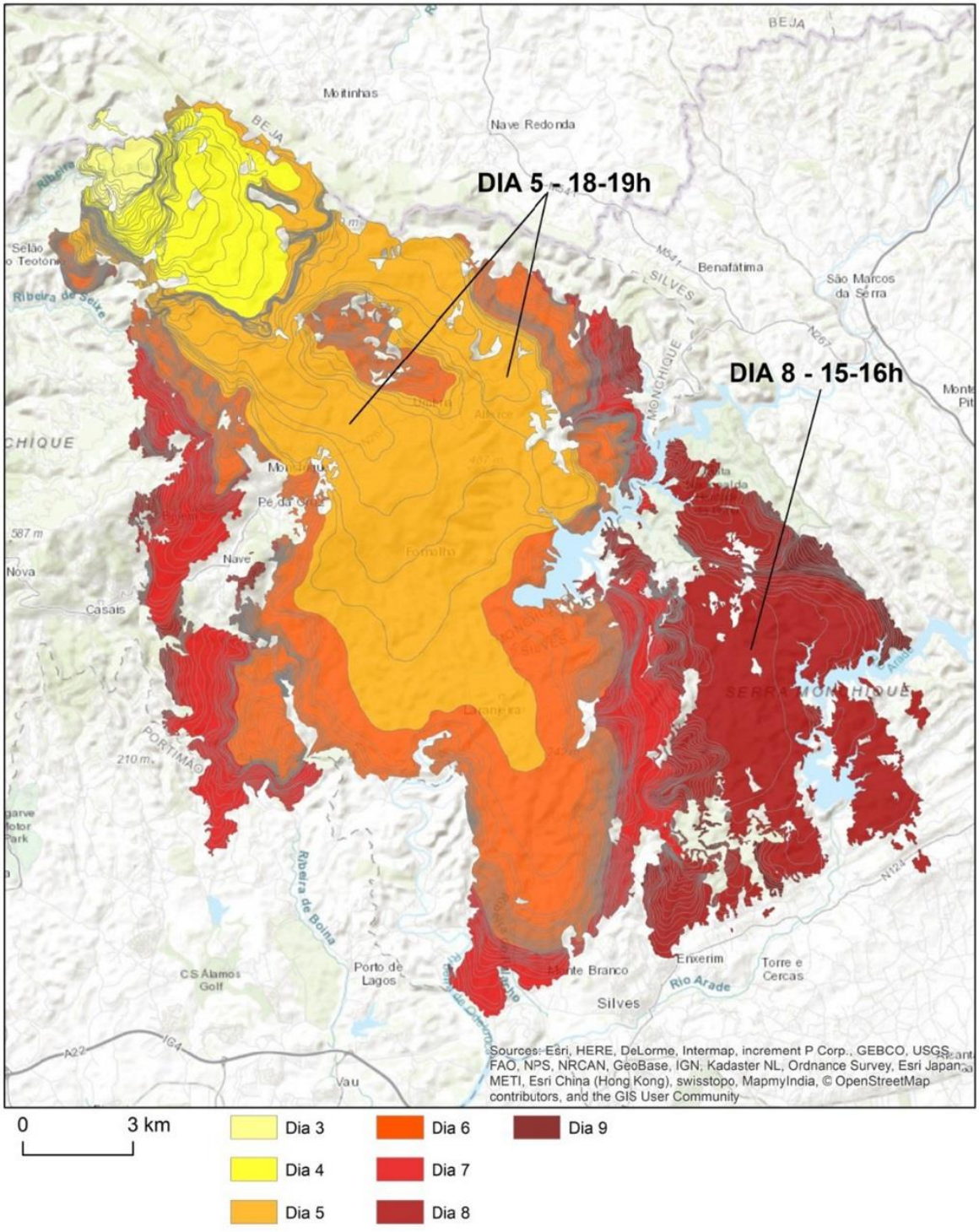
REPORT

Evaluation of the Monchique Fire



ASSEMBLEIA DA REPÚBLICA

OBSERVATÓRIO TÉCNICO INDEPENDENTE
para análise, acompanhamento e avaliação dos incêndios florestais e rurais que ocorram no território nacional

May 2019

REPORT

Evaluation of the Monchique Fire

Citação recomendada:
Observatório Técnico Independente, Castro Rego F., Fernandes P., Sande Silva J., Azevedo J., Moura J.M., Oliveira E., Cortes R., Viegas D.X., Caldeira D., e Duarte Santos F. - Coords. (2019) Avaliação do Incêndio de Monchique. Relatório. Observatório Técnico Independente. Assembleia da República. Lisboa. 78 pp.

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1. Introduction

The Independent Technical Observatory was set up by the Portuguese Parliament for the "analysis, monitoring and appraisal of forest and rural fires in this country, with the aim of making an impartial assessment of them, which will provide scientific support to parliamentary committees specialising in integrated rural fire management, civil protection, territorial planning, agriculture and rural development, forestry and nature conservation ", under Law No. 56/2018 of August 20th, amended by Law No. 1/2019 of January 9th.

Following this mandate, the Centre decided to draw up a report on the fire that started on August 3rd, 2018 in the Perna da Negra area, in the parish and municipality of Monchique, district of Faro, which went as far as the municipality of Silves. It affected an area of 27,154 hectares, and was brought to an end on 10th August.

It happened one year after the fires of June and October 2017, and despite there being no mortalities, the size and impact of this fire merit consideration as to how it grew and how the extinguishment was managed. This is set against substantial losses to infrastructure, forest resources, and the environment.

To this end, the Observatory made a detailed analysis of the fire, including visiting Monchique and Silves, gathering information from the main bodies involved in the pre-fire, the fire, and the post-fire phases, and various hearings with bodies involved in the incident.

Having analysed all of the information available, the Observatory completed the current report, which is intended to be a technical, scientific and independent contribution to an incident from which lessons should be drawn, resulting perhaps in a systemic improvement. Such an improvement should, in the Observatory's view, involve reforms in the management of rural fires, based on three structuring principles: the principle of co-ordinating fire prevention and firefighting, the principle of specialisation and the principle of professional skills training in integrated management of rural fires.

The Observatory would like to place on record here its sincere thanks to all those in the various sectors who gave their time and commitment to providing information as requested. Regrettably, the Observatory must mention the delays caused by the incomprehensible slowness of the Ministry of Internal Administration in sending us information requested from GNR in order to clarify their involvement in operations in this fire. We should mention here the

provisions in No 1 of Law no. 56/2018 of August 20th, which state that “the Observatory shall have access to all information necessary to complete its mission, with all public and private bodies being obliged to provide it in a timely manner, and to clarify additional information as requested. ”

In this context, the Observatory thus fulfills the task it was given by the preparation and dissemination of this Report on the biggest fire of 2018.

2. The context

2.1 2018 annual fire statistics

The best source for a historical analysis of the 2018 Monchique fire are the annual fire statistics for continental Portugal and in particular in the district of Faro.

Finding trends in the number of fires is always difficult because the criteria for registering them has not been consistent over the years. Figures before 2001 are underestimated compared to those after this date, because in the 1980s only occurrences greater than 0.1 ha of burned area were recorded, and in the 1990s only occurrences with areas greater than 0.01 ha. However, from 2001, all fires were recorded. Nevertheless, it is interesting to see what the official ICNF statistics show. The annual number of fires in the district of Faro peak at about 850 in 1991 and 1992, then drop, then enter a new period of high occurrences – 500-700 fires from 2006 to 2009 – then drop to reflect the national trend, but in the last two years this downward trend does not appear to reflect occurrences in the district of Faro (Figure 1). Then again, from 2013 to 2018, the number of recent occurrences is between 175 and 350, much lower than the figures for previous periods, both for mainland Portugal and in the district of Faro.

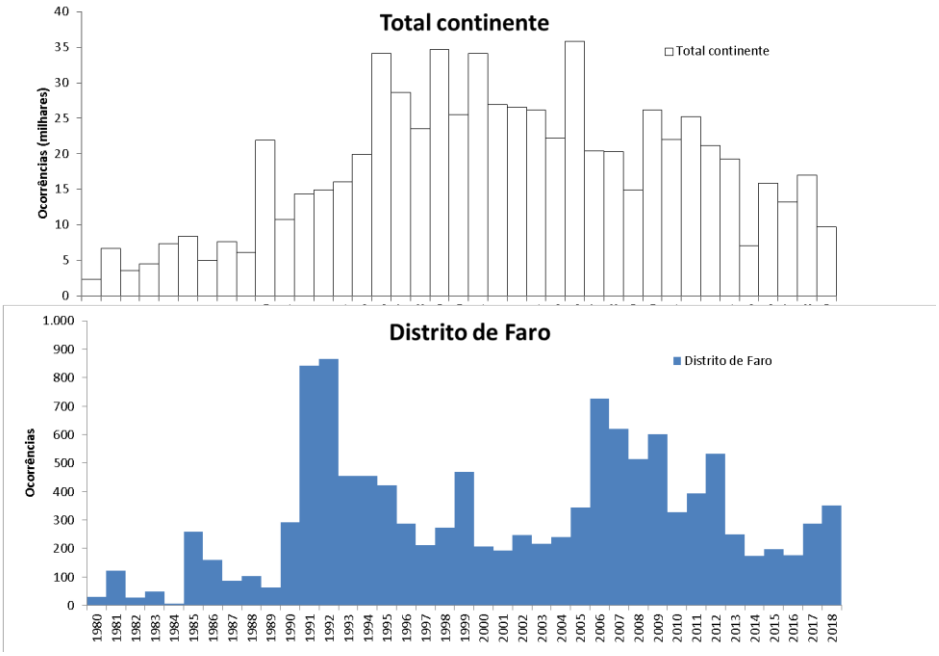


Figure 1. Evolution in the number of occurrences in the district of Faro (columns in blue) and in the total of the continent (columns without colour): Source: ICNF statistics. Note that for 2017, official figures refer to the period from the beginning of the year up to October 15th and, in 2018, up to September 15th.

Set against a longer term context, the areas affected in the district of Faro show a trend of unremarkable incidents not directly related to the total number of fires and quite distinct from the national trend of affected areas.
(Figure 2).

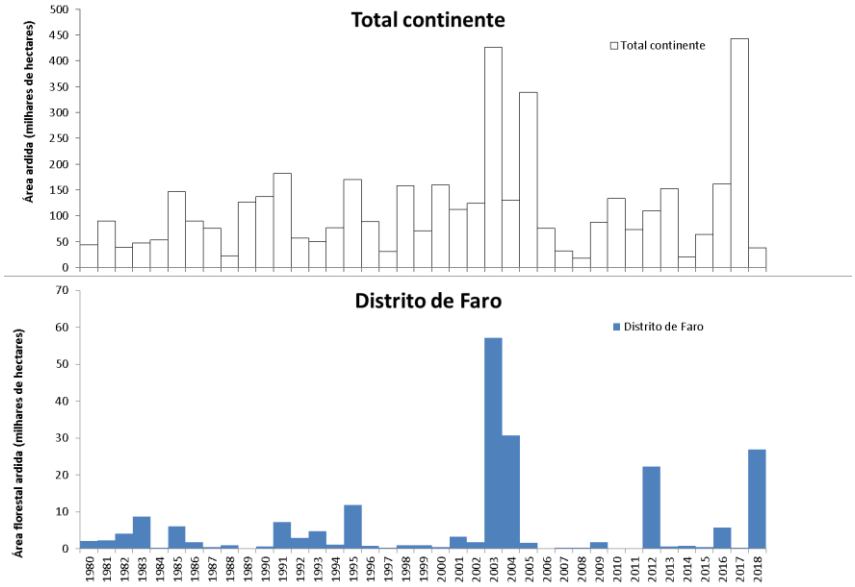


Figure 2. Trends in affected areas in the district of Faro (columns in blue) and mainland Portugal (columns without colour). Source: ICNF statistics. Note that for 2017, official figures refer to the period from the beginning of the year to October 15th and, in 2018, to September 15th.

As in the rest of mainland Portugal, data on affected areas in the district of Faro is greatly influenced by major fires. In the Faro district, 2003 saw the largest area affected by fire (nearly 60,000 hectares), following the national trend. However, in other years such as 2005 and 2017, the district of Faro did not reflect national trends as the area affected by fire was much smaller than the rest of the country. Likewise, there was no correlation with these trends in the years when the district of Faro had the largest area of land affected by fires, as in 2004 when more than 30,000 hectares were burnt; or in 2012, when a single fire in the municipalities of Tavira and São Brás de Alportel consumed an area of more than 20,000 hectares and was the subject of a specific report (Viegas et. al. 2012).

This dissonance between the district of Faro and the rest of the country is particularly marked in 2018, when, in the time period leading up to September 15th, the ICNF recorded more than 38,000 hectares burnt on the Portuguese mainland. Of these, approximately 27,000 hectares were in the district of Faro (Figure 2).

Furthermore, virtually the entire area burnt in the Faro district at that time was about the same size as the area affected during the Monchique fire examined in this report.

This context is important in helping us to see that, on a national level, the Monchique fire resulted in the greatest area of fire damage recorded. This has important implications which will be covered in this report.

It is equally important to consider factors associated with scrubland and woodland in the areas affected by forest fires from a historical perspective. Here, the report clearly shows that wooded areas were the hardest hit by the fire in the district of Faro, particularly during the Monchique fire, and they were more heavily affected than in previous years (Figure 3). Interim figures from the ICNF suggest that about 10,000 hectares of scrubland and 16,000 hectares of woodland were affected, in addition to 1,000 hectares of farmland.

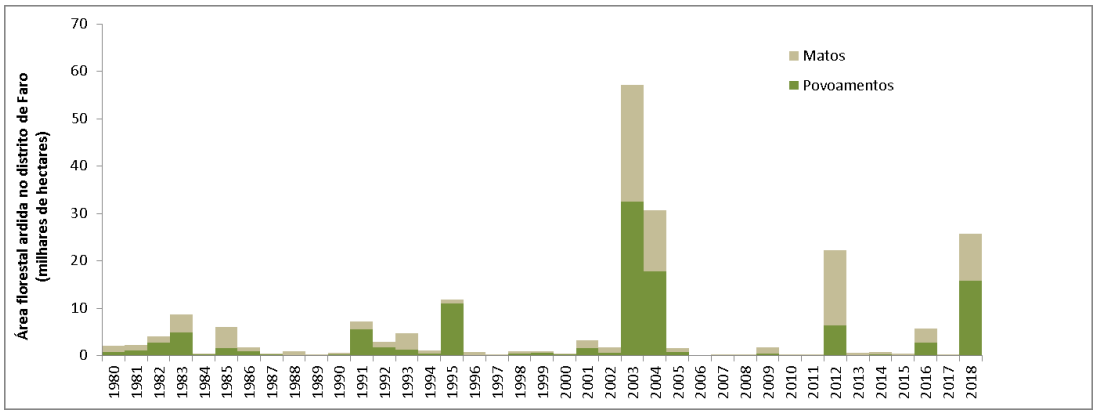


Figure 3. Changes in the areas of scrubland and burnt woodland in the district of Faro. Source: ICNF Statistics. Note that for 2017, official figures refer to the period from the beginning of the year up to October 15th and, in 2018, up to September 15th.

It should also be noted that, in the Monchique fire report, it emerged that the area of ground affected by the fire was essentially the same in 2018 as in 2003 (around 80% of its magnitude) which points to 15 years of considerable build up of biomass fuel, particularly timber, which had not been properly managed. In fact, a spring 2018 study carried out by several specialists from the University of Lisbon (Turkman et al. 2018, Pinto et al. 2018) found that due to the accumulation of combustible material in the area, the municipality of Monchique topped a national list of councils most likely to be re-affected by another major fire. So the writing was on the wall.

2.2 Weather and fires in 2018

Trends in areas affected by fire on the Portuguese mainland in 2018 can be analysed in terms of frequency and meteorological conditions.. The graph in Figure 4 breaks down the 2018 trends along these lines, and compares them to median and maximum figures.

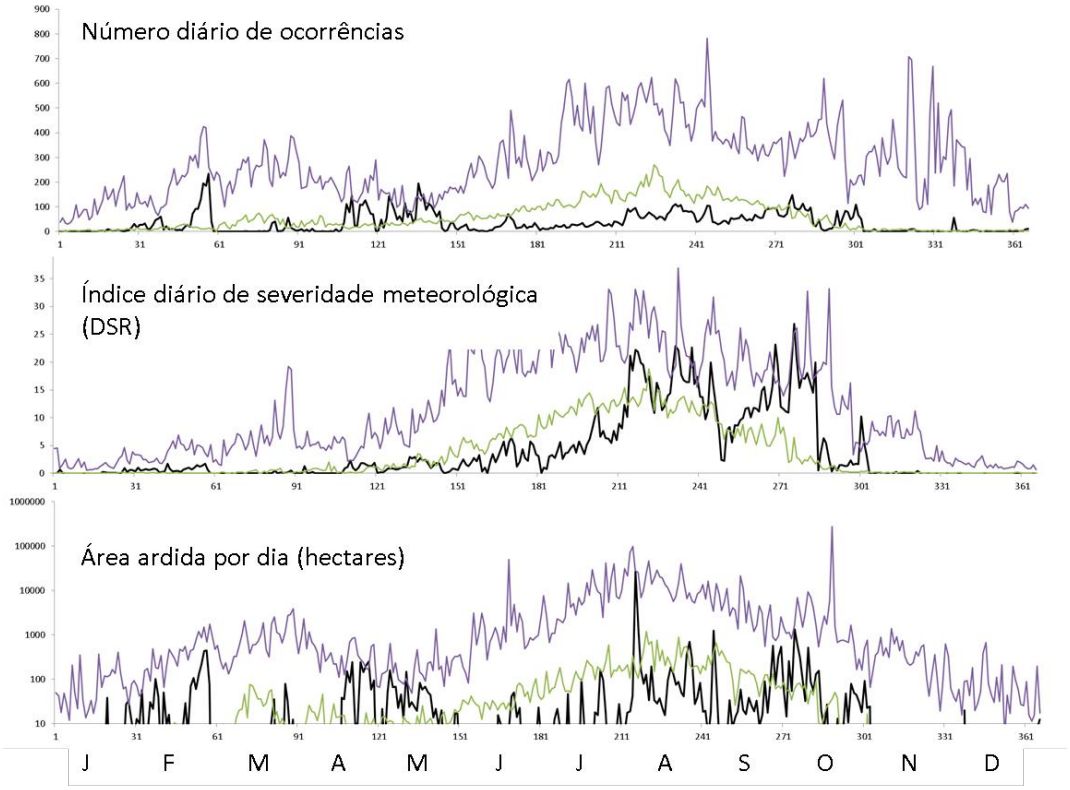


Figure 4. Daily changes in the number of occurrences on the Portuguese mainland over 2018 (top graph), the value of the DSR index of meteorological severity (middle graph) and of the area affected by fire, in hectares on a logarithmic scale (bottom graph). All graphs show the changes in 2018 (in black) compared to the median value (green) and to the maximum value (blue) in the period 2002-2017. Data from SGIF - ICNF.

The graph in Figure 4 is illustrative of the situation throughout 2018. In terms of frequency, figures are clearly lower than the median of the period 2002-2017 from June to September, with higher values in February, April, May and October.

Weather-wise, 2018 was far more favorable than previous years - until the start of August and the rapid onset of extreme weather conditions.

The area burnt in 2018 was greater than the average of the previous months (February, April and May), corresponding with the trend in frequency over that period, but never reaching exceptional levels, remaining below the index of extreme meteorological conditions. At the beginning of August and during the period from late September to mid-October, there were some severe conditions, with the area of land affected by fires surpassing the average of the previous period.

The graph in Figure 4 clearly shows that in early August, at the time of the major Monchique fire, the increase in the severe weather index was much higher than average, nearly a record high for

that period. The frequency of incidents over that period was low and therefore could not explain the extent of land affected in August. Clearly, the weather was the most important factor.

This well-known correlation between large fires and meteorological conditions can and should be used for better long range forecasting and preparation. The outbreak, the extent and the severity of the Monchique fire examined in this report all correlate with the meteorological conditions that were forecast and monitored during the period in question. In fact, on August 3rd 2018, a Statement of Alert was declared across the country, and raised to SIOPS red level State of Special Alert for DECIR.

In the zone where the fire started, the IPMA forecast from the 3rd to the 5th of August announced dangerous weather conditions for fires, with an FWI index reading of over 64, significantly above the definition of extreme weather conditions for forest areas (FWI = 38) and in the most acute category currently adopted by the IPMA.

Since 2001, all fires exceeding 5,000 hectares in the Algarve started on days with a FWI index greater or equal to 68. Furthermore, the IPMA forecast on the modified Haines index, which gives atmospheric fluctuations and potential for convective fire spread, was 12-13; an extremely high reading and similar to that recorded in the Pedrogão Grande / Góis fires of 2017. The forecasts made by the University of Lisbon Faculty of Science 'CeaseFire' platform for August 3rd showed readings for humidity levels for the finer leaf compost material (FFMC), fire spread (ISI) and FWI above 95 percent for that day and region. Conversely, humidity readings for the vegetative ground cover (DMC), availability of combustible materials (BUI) and dry matter (DC) gave very low values for the time of year (5-10% or 10-25%), despite the fact that in absolute terms it would result in a total consumption of all combustible material there and reveal the need for follow up consolidation work on the perimeters.

Daily weather forecasting is always useful, not only for strategic preparation but also to support decision-making in different firefighting operations until the fire is put out. As will be seen later in the report, hourly updates of weather indices proved to be very useful and should be used much more in future.

2.3 Territorial planning

The country's land use is another key element, because much of the combustible material for fires results from this. Data from the 2010 National Forest Inventory for the whole of the Algarve region showed woodland made up of various species, dominated by stone/umbrella pines (27%), cork

oaks (23%), holm oaks (7%), eucalyptus (21%) and other hardwoods such as carob and arbutus (19%).

The Algarve Regional Forestry Planning Program (PROF), which has been in force since February 2019 and bases its information on outdated 2010 data, designed an overall maintenance plan with the above ratios, with some reduction in the proportion of eucalyptus, offset by a slight increase in cork and other hardwoods. The previous version of PROF, developed in 2006, aimed at an even smaller proportion of eucalyptus forest, mainly due to the increase in the proportion of other hardwoods (Figure 5). The Observatory has already made its assessment of the PROF in a previous briefing note, and therefore does not make any further analysis in this report.

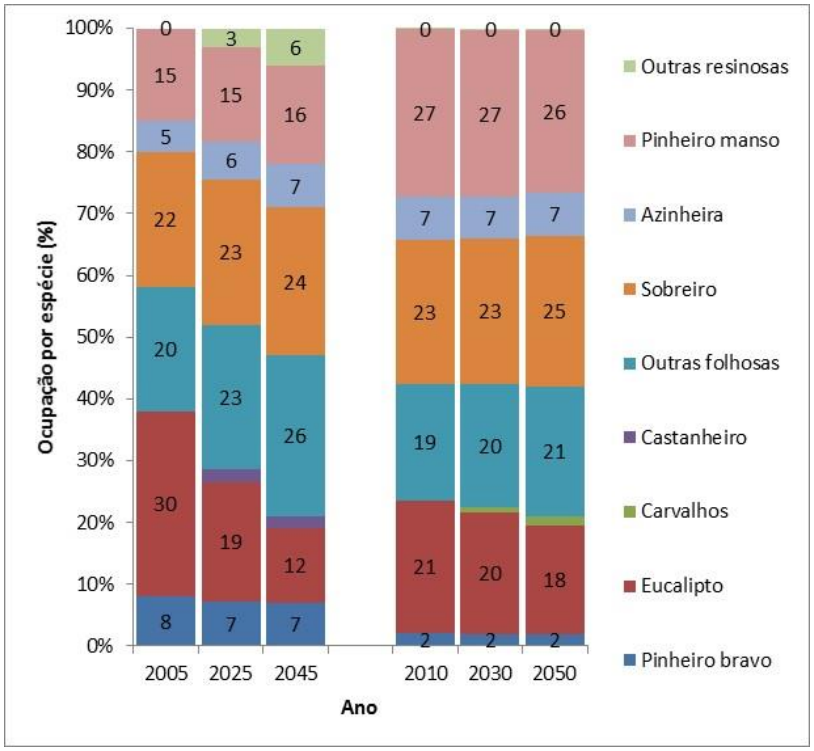


Figure 5. Anticipated comparative trends in the composition of Algarve forestry, compared to the first PROF based on 1995 data (first three columns), for the second PROF, where the 2010 composition was used in 2018 as the basis for its revision (second group of three columns).

The situation in the territory is not, however, the same throughout the Algarve. The Monchique mountain range subregion, which was one of the worst-affected parts of the 2018 fire, was dominated by eucalyptus trees (40%) and scrub growth (40%), with cork oak taking up 2% of the total surface area. This reflects the enormous potential for combustibility in this area. On the

other hand, in the subregions of Serra de Silves and Meia Serra (40%), scrubland continued to occupy much of the surface area, but here a greater diversity of forest species could be found. In the Silves mountain range, cork oak covered 15% of the area and eucalyptus 5%, while in Meia Serra, eucalyptus accounted for 15% of the area, with an identical value for stone pine.

With regards to this territory, it is understood that the fire affected area was mostly scrub (35%) and eucalyptus (35%), with a significant area of cork oak woodland (15%).

The availability of combustible material, as well as the composition and layout of the forest, are very relevant in terms of the spread of the fires. In the fire under review, the westward spread on the left bank of the Odelouca was limited by there being less combustible material left since the previous major fire in 2016. On the other hand, when compared to the Serra of Monchique, the greater diversity and fragmentation of the forest areas in the Serra de Silves area and particularly in Meia Serra will have helped limit the spread of the fire further south and southeast. We will resume this analysis in an hour-by-hour development of the fire as it spread.

2.4 Pre-fire management of combustible material

A progressive build up of large volumes of combustible material always leads to a heightened risk of local fire. This finding has led to the search for solutions, with a greater focus on territorial infrastructure, to find ways of minimising those risks. As such, emphasis has been placed on building and maintaining a primary network as an essential part of a web of fuel management fire breaks set out on a large scale. The design of a primary network and patchwork landscape would allow us, with the use of historical reconstructions of recurrent fires in the area, to model the spread of fire so that we might uncover strategic management points that would merit their own consideration in the Regional Forestry Programs.

For the setting up and maintenance of a primary network, local authorities are best placed to facilitate funding tools in order to implement this. Although this was one of the goals outlined by the PNDFCI in 2006, the route of the primary network was only finalised on a national level in the first quarter of 2013, in accordance with the PNDFCI Mid-Term Review (2006-2012), and only a small part of this was actually carried out. That delay had relevant consequences for the early stages of the Algarve primary network.

But perhaps even more fundamental than the primary network is the diversification of species and their patchwork distribution, and the reduction of accumulated combustible material, focusing instead on woodland management and preventive measures whilst taking advantage of the

potential for complementary activities such as the extraction of resin, biomass for heating/energy, silvopasture, or others. Without these alternatives ways of using combustible material, the build up of composting biomass is inevitable. Under the right weather conditions, this leads to fires with the intensity of the one examined in this report occuring every 15 to 20 years.

In the affected area, they had not been maintaining fire breaks. By this, we mean corridors running in a roughly straight line, often following high contour lines or river valleys, thus ensuring a continuity of ecological activity between core areas for better nature conservation and fire protection. These corridors encourage landscape diversity and the partitioning of stretches using natural forest ecosystems (balanced with climatic and soil conditions of each territory) and agro-pastoral landscape factors. Such corridors could have worked as breaks in the management of combustible material, to prevent rural fires.

The management of combustible materials is a fundamental part of the city's Municipal Forest Fire Defence Strategy. An analysis of Monchique council's PMDFCI (2016-2020) reveals that priority areas had been identified for the management of combustible materials (designated by combustible categories 5 and 6, mainly scrub) and areas of heightened danger (Figure 6), which are precisely the areas that were most affected by the fire examined in this report. Indeed, by looking at the map of high danger areas, you can see that the areas with the highest danger levels (category High Risk) were on the west part of the municipality of Monchique, where it meets the municipality of Aljezur, and in the southern part where it meets the municipality of Portimão, in addition to the High Risk zone that extended from the areas of Foia, Madrinha, Cimalhas, and Cerro do Lobo up to Cerro da Esteveira - the same parts affected during the first phase of the fire.

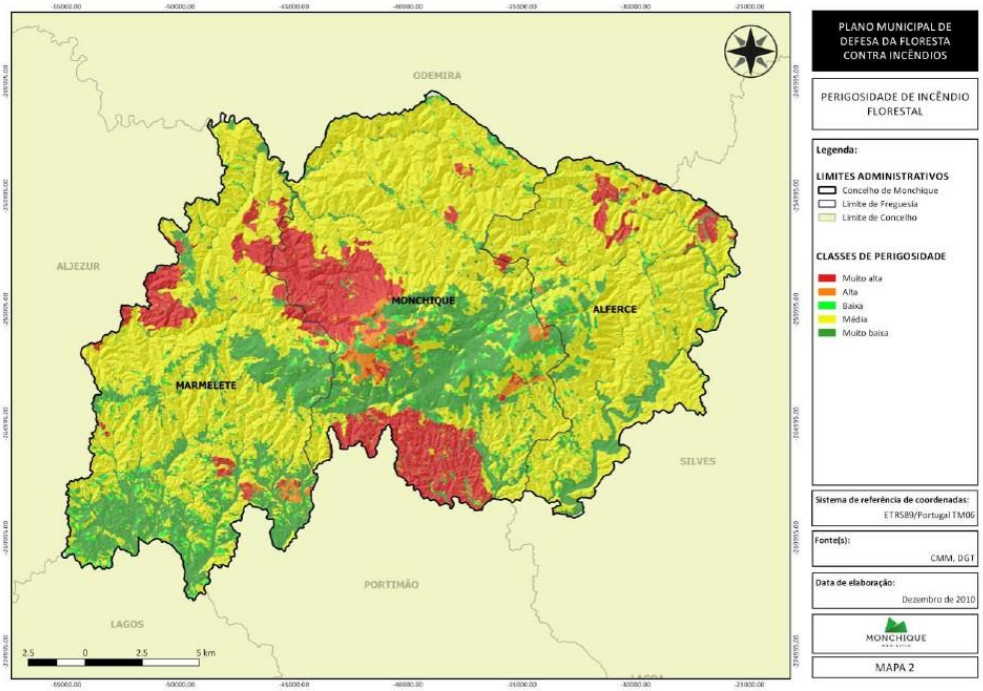


Figure 6. Forest fire hazard map Monchique PMDFCI (2016-2020).

What stands out from an analysis of the PMDFCI Fire break Network Management of Combustible Materials (FGC)(CMDFCIM 2015) is that in Perna Negra where the fire started, there is a high tension (15 kV) electricity cable firebreak. However, it is classified as “no action needed” for the five-year period between 2016 and 2020 (Figure 7) in that local authority plan. The reason for the PMDFCI’s classification of “no action needed” is not known, although EDP is the body concerned. It should be noted that the point of this firebreak is to lessen the chance of ignition resulting from contact between combustible materials (trees) with live electrical cables. It is obligatory to have “Firebreaks no less than 10 metres wide on either side, in forest areas as defined in the PMDFCI”(ICNF 2010) .

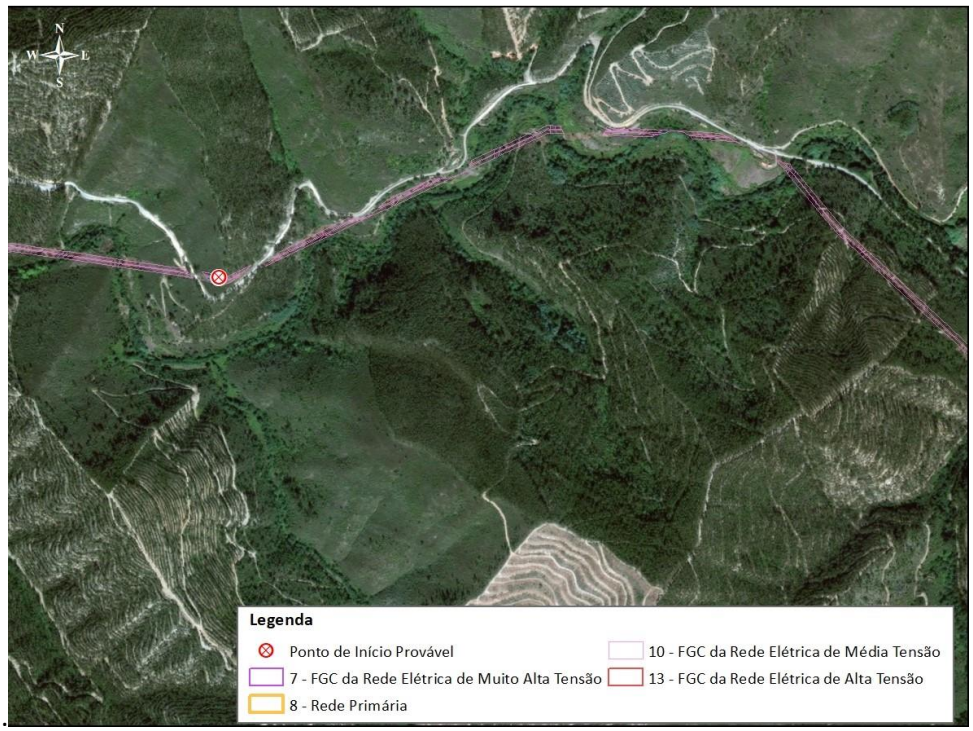


Figure 7. Firebreak in the high tension electricity grid in the Monchique PMDFCI with the place where the fire probably started is shown. Author's own work: Independent Technical Observatory, 2019. Source: PMDFCI de Monchique 2016 - 2020 (CMDFCIM 2015).

In populated areas, it was found that fire breaks do seem to have been effective in having a direct impact on the spread of fire (even though their size does not, for the most part, comply with the legal requirements, defined by PMDFCI: not less than 100 meters). But the greatest risk is associated with projections over the roof of buildings and combustible materials next to them, resulting in eucalyptus trees catching fire. Figure 8 shows the existence of FGC in the village of Alferce, which was cut off during the fire.

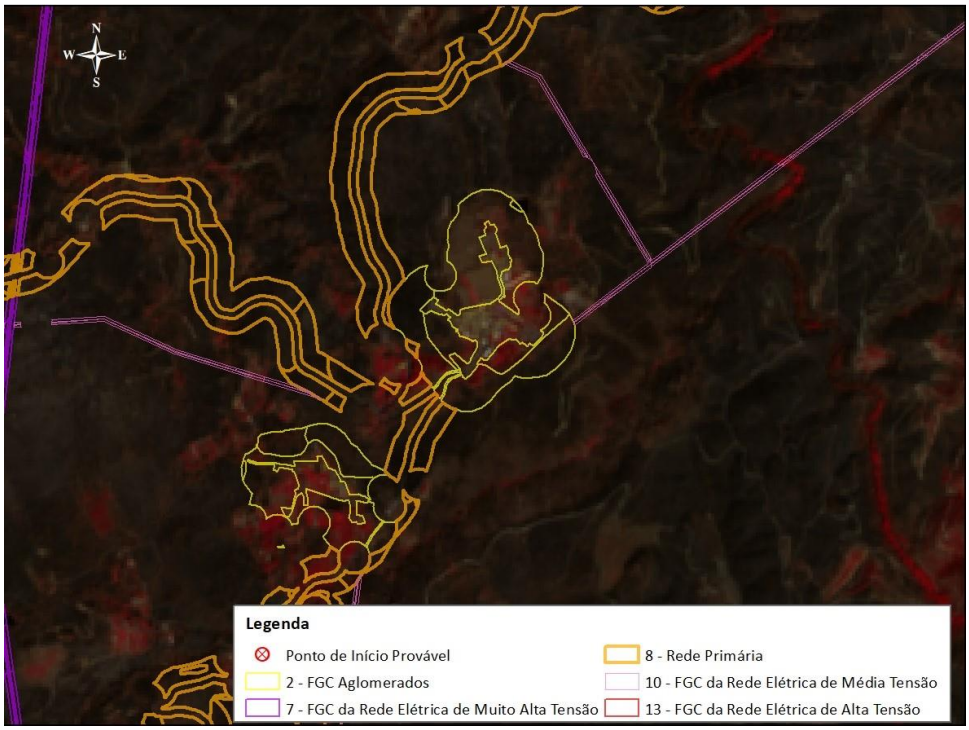


Figure 8. Firebreak around the village of Alferce. Author's own work: Independent Technical Observatory, 2019. Source: Monchique PMDFCI 2016 - 2020.

In the case of the Primary Network Firebreak Management of Combustibles, the project was started about 15 years ago but its implementation has been hampered by commercial forestry companies in the eucalyptus areas (as the PMDFCI of Monchique pointed out and as emerged in meetings with the local authorities). In the municipality of Monchique, the primary network of firebreaks had already been defined for each parish, representing a total of about 2,500 hectares, over 6% of the territory. However, only a small percentage of that would have been implemented.

It should also be emphasised that the FGC Primary Network layout would not have followed all of the technical requirements for proper implementation, as can be seen from stretches of this network on the EN266, EN267 or EM501 roads, among other examples (Figure 9). The layout does not seem to have sufficiently taken into account factors such as prevailing winds or previous history of fire, topography and land use, and the probable skills and safety of the fire fighters. The considerable time the fire lasted, the route it followed, land use, and the land tenure there also posed a challenge to this DFCI infrastructure, and ended up nullifying or reducing its efficacy.

The efficacy of the Primary Network as a passive means of containing the fire would always be compromised, especially when land use plays an important part in settlements with a high fire risk.

Such places often have no fire protection programme, so that when they experience strong winds in deep hills and valleys, fires become more and more intense with a lot of projection, and this type of fire becomes impossible to contain. An earlier study (Oliveira et al. 2016) revealed that if the Algarve Primary Network was fully implemented, it would reduce the total area burnt by only 17% and the likelihood of burning between 4% and 31%, with 26 ha of treatment required for every hectare of land saved. The efficacy of the Primary Network is therefore largely dependent on its use in firefighting.

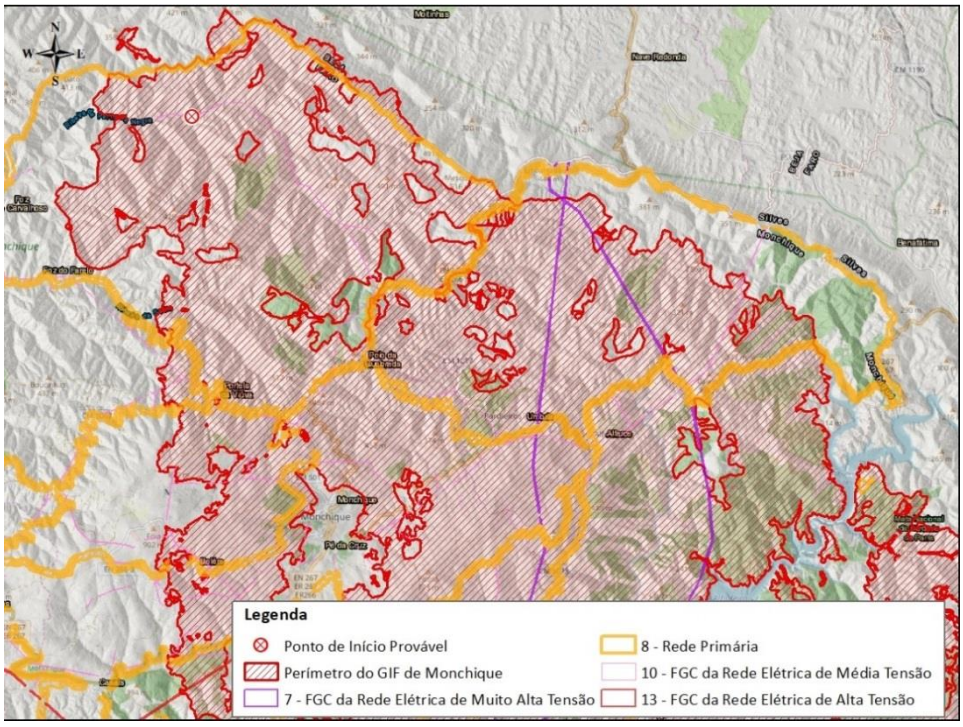


Figure 9. Design of the FGC Primary Network in the area affected by the Monchique GIF. Only part of this network was implemented in 2018. Author's own work: Independent Technical Observatory, 2019. Source: PMDFCI of Monchique 2016 - 2020.

In the municipality of Silves, they bet equally on the secondary and tertiary networks, with the parishes of São Marcos da Serra and Saint Bartholomew of Messines being considered a priority. Meanwhile, to the north of the town of Silves, in Odelouca, Vale de Lama and Falacho, up to June 2018, 110 hectares with fire protection management were set up, although this was obviously not enough considering the huge amount of combustible vegetable material. At this time, the extent of the firebreaks (FIC) had reached 65 km (150 hectares) as a result of approval of applications submitted by the Municipality to the Permanent Forestry Fund (FFP). The FIC were therefore

implemented in the areas bordering the municipalities of Ourique, Odemira, Almodôvar and Monchique, and in connecting up the parishes, particularly the stretches: Fitos / ValeTouriz / Benafátima, Azilheira / Santa Maria / IC1, Monte and Azilheira / Perna Seca / ICI. What stood out at the time of the fire was the improvement of 125 km of forest paths, particularly in the Herdade da Parra and the area surrounding the National Breeding Centre for Iberian Lynx (CNRLI). As in Monchique, the conclusion is that in fires of this intensity and size, the existence of these firebreaks neither limits nor increases the amount of area burnt.

3. The fire

3.1 The start of the fire

Information on how fires start is often subject to controversy and uncertainty. In the intricate play of factors that result in an area getting burnt and the consequential damage to people and material goods, the cause of the fire is at the root of it all and determining this can have huge consequences in terms of civil and criminal accountability. This liability will of course be commensurate with the damage caused. For this reason, investigation into potential causes is carried out by the appropriate bodies of the GNR and the PJ. Once they have determined the causes, they submit them to the System for Management of Forest Fires (SGIF) managed by ICNF.

According to SGIF data, the district of Faro recorded a total of 711 occurrences in 2018, of which 357 (about 50%) will have been investigated. The degree of detail present in these investigations has already been the subject of a previous report by the Observatory. In any case, of the causes investigated, 40% are related to the use of fire, 15% are accidental causes, 9% concern arson and 40% are undetermined. Only fires with natural causes and fires due to re-ignition are registered. Ignition from power lines (code 211), accounted for 9% of all causes investigated in the District of Faro in 2018, and was the most frequent accidental cause.

Regardless of the investigations, the fire under review here illustrates the difficulties inherent in clearly and unequivocally ascertaining the cause of fires. At the time of writing, the cause of the fire under review (Perna da Negra - Boavista) is still classified as “unknown”.

This Observatory has neither the remit nor the competence to do the technical work necessary to discover the cause, so we rely on information from other bodies. But we naturally include in this report our impressions from a visit we made in February this year, of the place we were shown where the fire is likely to have started (Figure 10).

Furthermore, there are early photographs where flames are visible near to the place we were shown, and indications that the power line may have been the source of the fire, due to the fact that there are trees – eucalyptus – with enough height to be able to make contact with the power cables (Figure 10), even though EDP’s version of events does not include this observation. Despite evidence that suggests that the fire may have originated from the medium voltage line running through the place where the fire started, no official information exists on more detailed findings that might confirm this hypothesis.

Figure 10. Probable location where fire started (Lat: 37.396944, Long: -8.588963; SGIF record) under a medium tension (15kV) power line managed by EDP.

The management of combustible materials associated with these firebreak networks has already been covered in a previous chapter (2.4) where it can be seen that the firebreak in question is outlined in the PMDFCI but without mention of any action required.

It should also be noted that according to the ANPC Preliminary Operational Report on this fire, the CNOS was already warned of fire ignition by power lines in Monchique on July 30th , August 1st and August 2nd . On August 3rd, there would have been a "Meeting with EDP's liaison officer responsible for low and medium tension lines, in order to strengthen preventive and anticipatory measures in order to mitigate the risk of fire." In the same report, from August 3rd, it is noted that a pair of Fire Boss aircraft were mobilised for military surveillance of the region.

The GNR Report, which was given to us on April 20th , indicates on pages 31 - 34 that the start of the fire was near the 15 kV power line that we referred to, and shows photographs of the site, which leads us to conclude that it is the same place as in outlined in this Report. SEPNA agents report that despite not being able to find any eyewitnesses to the start of the fire, they did obtain relevant information on how it started. There was no evidence to attribute the cause to the negligent use

of fire. It did state, however, that ignition could have happened due to direct contact with flames, although they do not substantiate this. Due to insufficient objective evidence, SEPNA classified this fire as of undetermined cause. The SEPNA Report cites an account published by Portimão NPA, which "seems to indicate that the fire started in a place subject to compulsory management under the terms of 1 (d) of 15th of DL 124/2006, of June 28th". It also refers to EDP's obligations, under the Municipal Plan, to carry out at least one operation a year in that area.

In a report prepared by EDP Distribuição, the possibility of a link between the source of the fire and the power line under question is disputed. It is further noted that, in 2015, a contract for the management of power line firebreaks in the Perna Seca area was put into place, and found that no work was required.

In conclusion, although there is no confirmation as to the cause of this particular fire, statistics point to the serious issue of ignition from electrical power lines. In particular, the lines that cross areas with eucalyptus trees should be targeted for very careful attention due to the rate at which this species grows, allowing discharge by touch, and even facilitating damage to power lines.

On the other hand, we cannot fail to draw attention to how ineffective the investigation into the cause of fire has been. Nine months on, it is strange that there is still no known cause for a fire with the consequences that this one had. Therefore, we recommend an improvement in the service for investigating the cause of fires, especially the major ones.

3.2 Surveillance and Detection

"The National Watchtower Network (RNPV) is the backbone of fixed terrestrial detection of fires in Portugal. It is currently operated and managed by GNR and functions according to a two-phase timetable: manning of the primary network (in 2018 from May 7th to October 30th) and manning of the remaining lookouts from July 1st to October 15th. The logistics of the fire risk in terms of space and time, and the limited coverage of the territory covered by the RNPV, demands, or recommends, that this work be supplemented through mobile surveillance on land or from the air pending the potential for a fire to start and to spread. It falls to the ICNF to recommend additional surveillance in critical places and situations." (Observatory Report, 2018).

The place where the fire started is covered by three National Lookout Network watchtowers:

1. Watchtower in Vigia da Madrinha, Foia, Monchique (PV 82-01)

2. Watchtower in Picota, Monchique (PV 82-02)

3. Watchtower in Mesquita, Odemira (PV 63-08), not mentioned in the PMDFCI of Monchique.

When we look at the visibility areas of these lookouts, we can see that just like other parts of the country with the same terrain, a large expanse of the territory affected by fire is in shaded areas, and is not directly visible (Figure 11). This being so, a fire is only visible when the smoke column reaches a height where it can be seen.

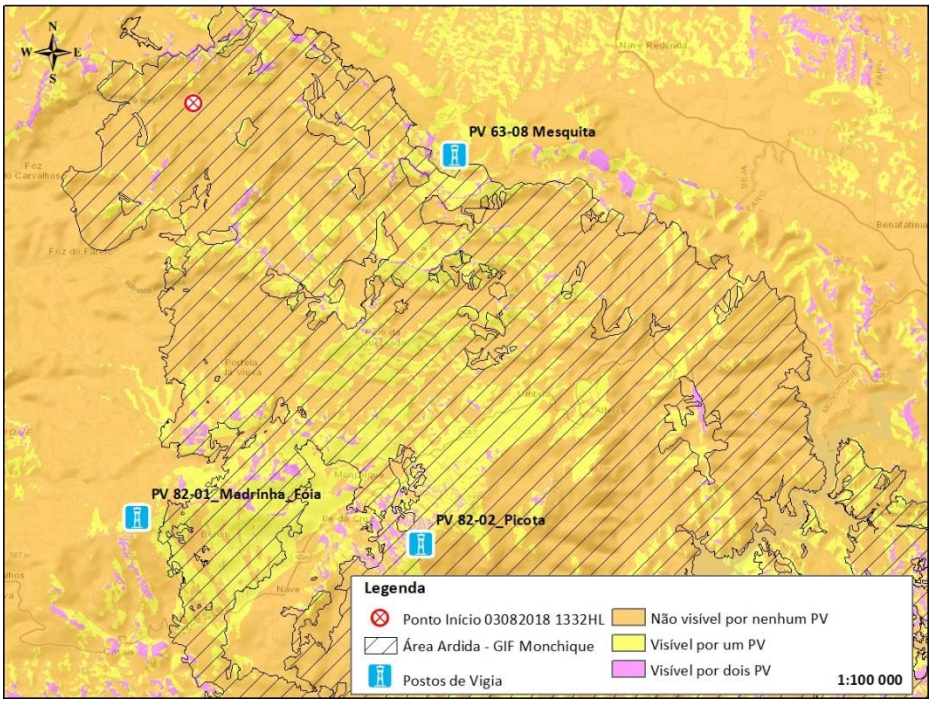


Figure 11. Visibility areas from watchtowers in the area where the Monchique fire happened.
Author's own source: Independent Technical Observatory, 2019.

With regards to this fire, the warning was sounded at 13:32 (local time), meaning that the probable starting point had a height of approximately 230 meters. The nearest watchtower at this location is PV 63-08, situated in Mesquita at a height of approximately 510 meters and at a distance of about 6 km. The second nearest watchtower is PV 82-01 in Madrinha - Foia, about 9 km away and at an approximate elevation of 850 meters and the last and the farthest is the PV 82-02, situated in Picota, at a distance of 11 km and an approximate elevation of 770 meters (Figure 11).

Due to the mountainous contours, with the deep valleys of Ribeira da Perna Negra and Ribeira de Seixe, and with the higher parts blocking the line of vision between the lookouts and the place where it started, it would appear that the field of vision between the watchtowers and the probable

starting place is zero (Figure 12). This would have contributed to the delay in detection, which would only have happened when the smoke plume could be seen from one of the watchtowers – which, in turn, means that the plume of smoke needed to rise high enough from the lower atmosphere to enter into the field of vision.

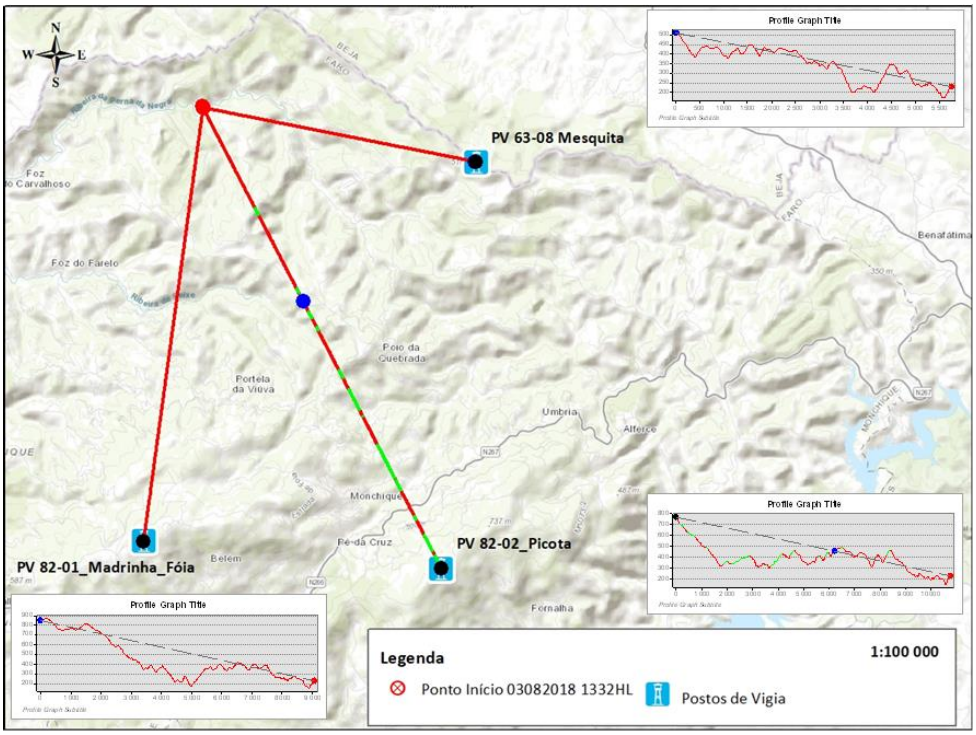


Figure 12. Views between the watchtowers and the probable starting point (green - visible; red - not visible). Author's own source: Independent Technical Observatory, 2019.

It must be stressed that Monchique PMDFCI itself acknowledges the difficulty in covering the local authority area through fixed surveillance and proposes using mobile surveillance alongside this: "Given that the watchtowers do not guarantee effective coverage of all the local authority area, fixed surveillance needs to be supplemented by mobile surveillance." In the same vein, the path that intersects the likely starting point of the fire was established as a mobile surveillance circuit.

It is also noteworthy that, according to the Special Report "Great Fires" prepared by CODIS in Faro, from July 28th to the date of occurrence (August 3rd , 2018) early warning operational measures were adopted, "some of which were set out in the relevant plans, as detailed in the daily Technical Operational Briefings (BTO) of the Faro CDOS, no.227/2018, 228/2018, 229/2018, 235/2018, 237/2018, and 239/2018 (Annex A1) ".

Let us remember that surveillance activity is coordinated by the teams from the GNR (Maintenance and Exploration of Forest Information Team- EMEIF), who are present in each CDOS of the National

Civil Protection Authority (ANPC). It would therefore make sense to evaluate the implementation of measures that have been adopted, which will only be possible when the Observatory has obtained information from the Municipality of Monchique, the GNR and the ANPC for this chapter, namely, the strategic sites identified for parking or pre-positioning, the mobile surveillance circuits established, and, in particular, the location of mobile surveillance units between 13:00 and 14:30 hours on August 3rd, 2018. Without this information, we will not be able to assess how well this work complements the work of the watchtowers.

It is strongly recommended that information on the positioning of mobile detection is permanently recorded. Only through lessons learnt this way can the system be improved and optimised.

3.3 Spread of the fire and contributing factors

3.3.1 Spread of the fire

We can now use satellite imagery to study the growth of the fire, giving us better pictures and a clearer understanding of the incident. Figure 13 gives us an overview of the spread of the affected area from August 4th to August 9th.

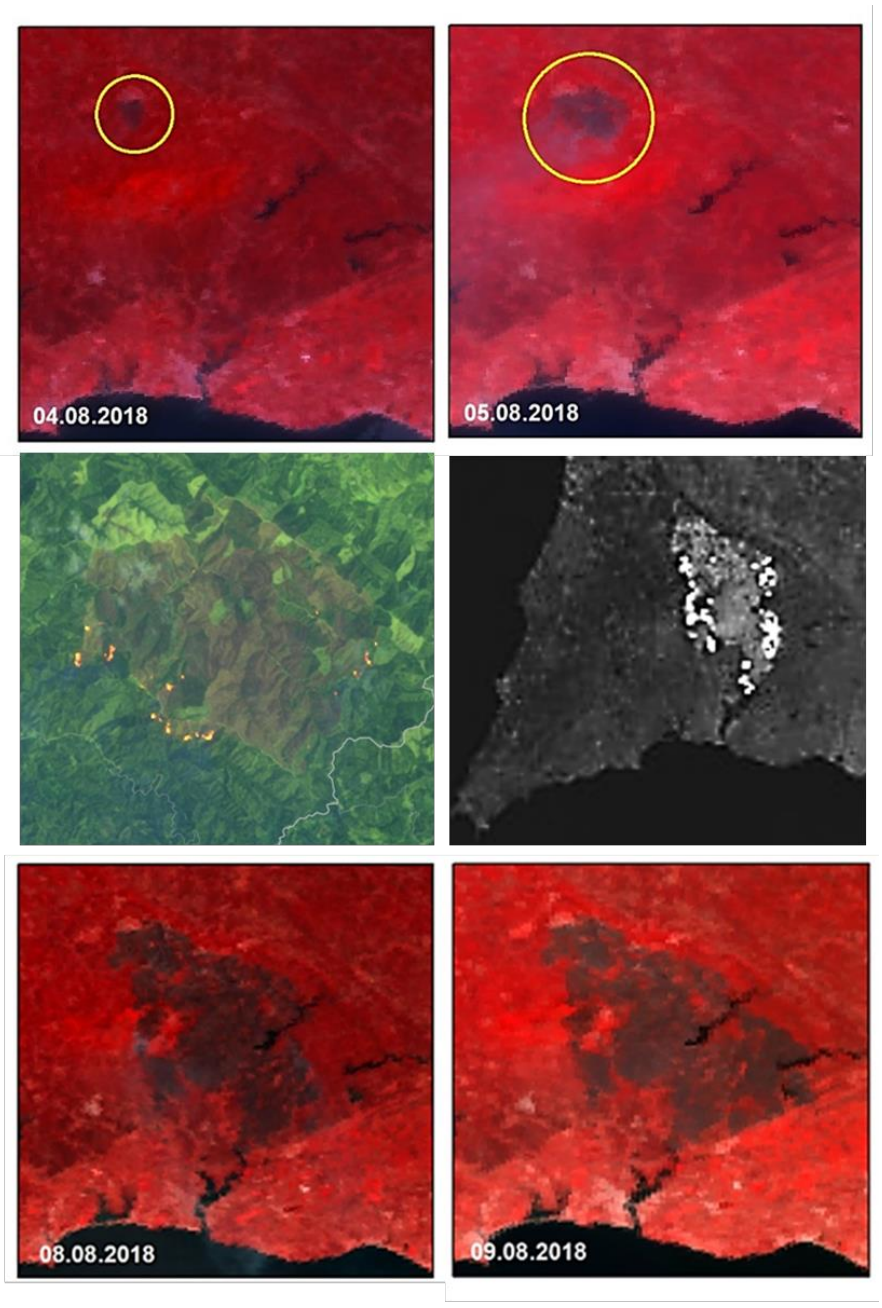


Figure 13. Images obtained from the Sentinel 3 satellite between 10:00 and 11:00 on 4 and 5 August, (top images) and on 8 and 9 August, 2018 (images below). Source: COPERNICUS, European Space Agency. Middle left Landsat image, late in the morning on August 5, 2018. Source: USGS. Middle right image of 7 August 2018 from VIIRS (middle infrared). Source: European Space Agency.

This sequence shows how small the affected area was on the morning of the 4th, and its significant increase in size on the 5th. The Landsat image shows us a set of warm spots that would give rise to further developments. The fire continued to burn, and on August 7th, a large number of well-documented, active fires can be seen at the perimeter. The spread of the fire continued with

the image showing the affected area on August 8th. Up to the morning of August 9th, the fire still extended eastward, as shown in the picture, and did not change shape after this.

In addition to looking at the history of the fire's shape, some satellite images also give us an idea of the power of the fire through its radioactive strength (FRP). This figure for the fire in megawatts was calculated on an hourly basis, using the highest figure from the four readings taken every 15 minutes by the SEVIRI radiometer, which was on Meteosat Second Generation, MSG. With this method, an increase in the strength of the fire can be seen from when it started on August 3rd to the end of August 9th 2018. (Figure 14).

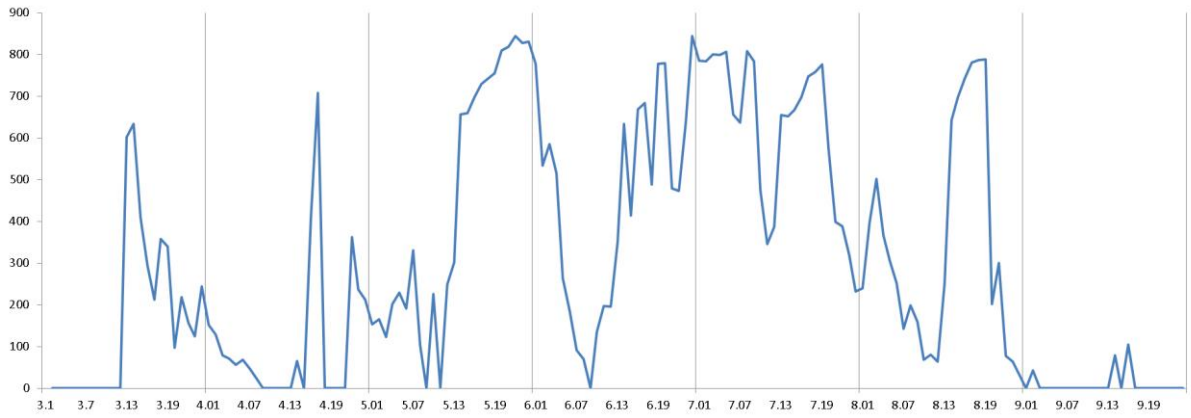


Figure 14. Growth in radiactive power (FRP) (in megawatts) of the Monchique fire from the 3rd to the 9th of August 2018. Graph produced from data provided by Prof. Carlos da Câmara (University of Lisbon) (https://meetingorganizer.copernicus.org/EGU2018/EGU2018-15968.pdf).
In the graph, the vertical lines represent the days. It shows that the fire was practically inert on the morning of 4th, and on the mornings of 5th and 6th, providing windows of opportunity which are referred to in another chapter.

A more detailed reconstruction of the spread of the fire, undertaken with the help of Engineer Nuno Guiomar (University of Évora), used over 2000 data points sourced from field-based information and remote sensing technologies. The result is Figure 15, which summarises the geographic and chronological history of the fire. The isochrones, or time tracking, of the growth of the fire enable us to see when the fire was at its maximum growth. Superimposing the areas that got burnt on an hourly basis with a map of land use shows us what burnt, and when it burnt.

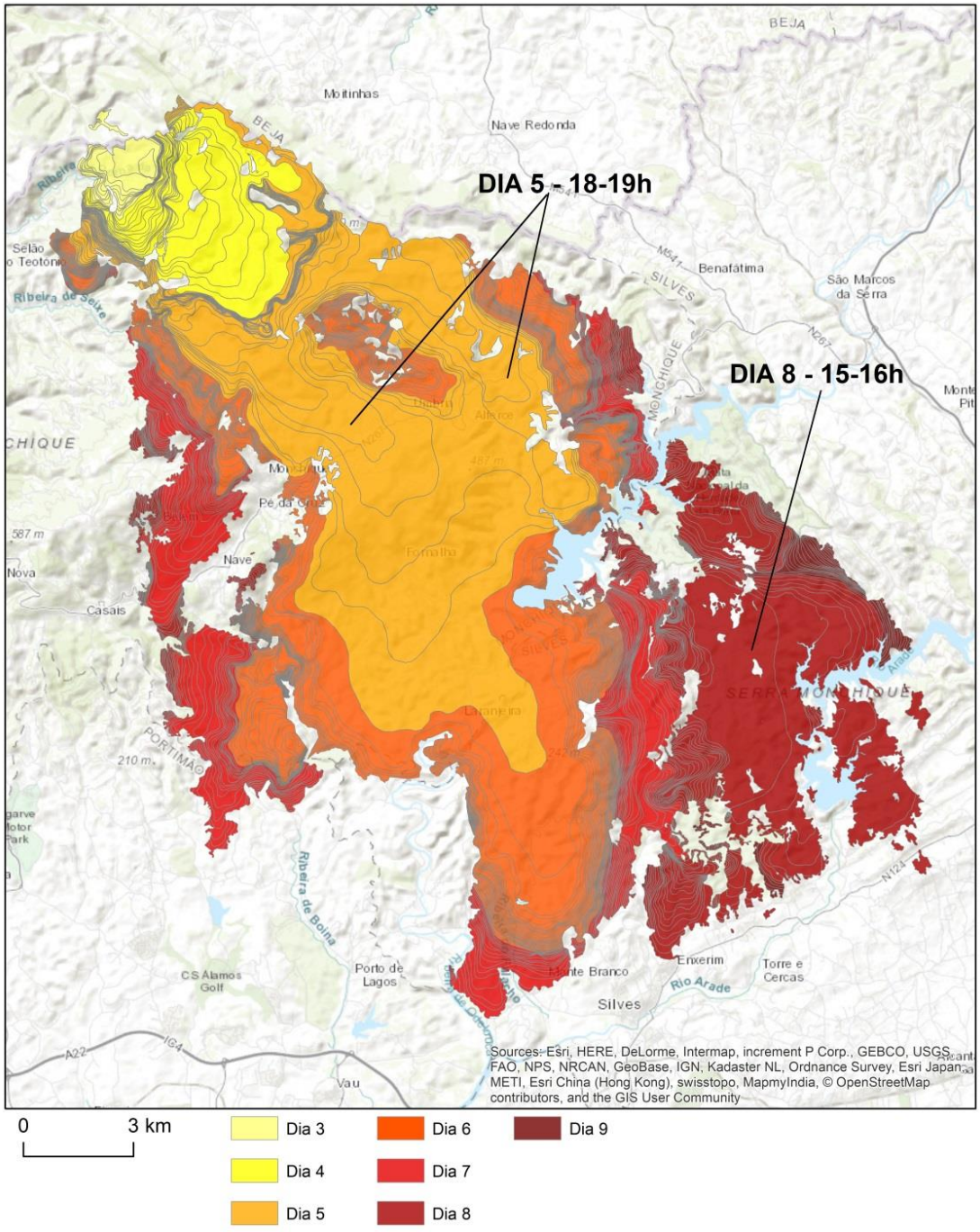


Figure 15. Hourly and daily reconstruction of the growth of the Monchique fire, showing the large expansion of the fire on 5 and 8 August.

Figure 15 shows that, on the day the fire started (August 3rd), it spread predominantly to the west, having burned 325 ha in about 10 hours. On August 4th, with a northwesterly wind which would continue and set the NW-SE orientation of the fire, it covered another 1,719 ha, with the most significant expansion between 20:00H and 24:00H. However, the fire was at peak growth on August 5th, with an estimated 8,587 ha, or 31.6% of the total area burnt. On August 5th, the

fire developed mainly during the last 6 hours of the day on two fronts, separated by a patch that did not burn until August 6th. The western front reached the town of Monchique and covered 15.6 km in 6 hours, giving an average speed of spread of 2.6 km / h. The eastern front would impact the village of Alferce (which remained cut off following the spread of the right side of the western front, and which had no help from the fire brigade for about 5 hours) and progressed 9.4 km in 3 hours (3.1 km / h). Between 18:00H and 19:00H, it almost reached 4 km / h, which was the fastest speed recorded. It was only the Odelouca dam that eventually stopped its advance.

Depending on the speed of growth and the amount of fuel burnt, the intense heat of the flames at the front of the fire would have ranged from 15,000 to 60,000 kW/m during the most critical periods. These figures are well beyond the capacity of aircraft to extinguish. This most severe phase of the fire occurred during the first two hours of 6th and overall, over 8 hours, the fire advanced almost 20 km in the western area. From then on, and until around the end of August 7th, the fire progressed along its sides and without major fluctuations in its rate of growth, which averaged 166 ha/h.

During the morning of 8th, the rate of fire growth was lower or similar to that of the previous day. However, it flared up between 16.00H and 20.00H, during which time 3,069 ha burnt, and at the end of which 96.7% of area affected the fire had been burnt (27,154 ha). This growth (which reached 2.1 km/h in the first hour) was mostly along the east side to the Arade reservoir, and in a northeasterly direction because the west side had been affected by a major fire in 2016.

Despite the fire going on for so long, a huge difference in the rates of growth within the area affected is quite obvious. In fact, 62% of the total surface area affected was burnt during just 16% of the total duration of the fire, as shown in Figure 16.

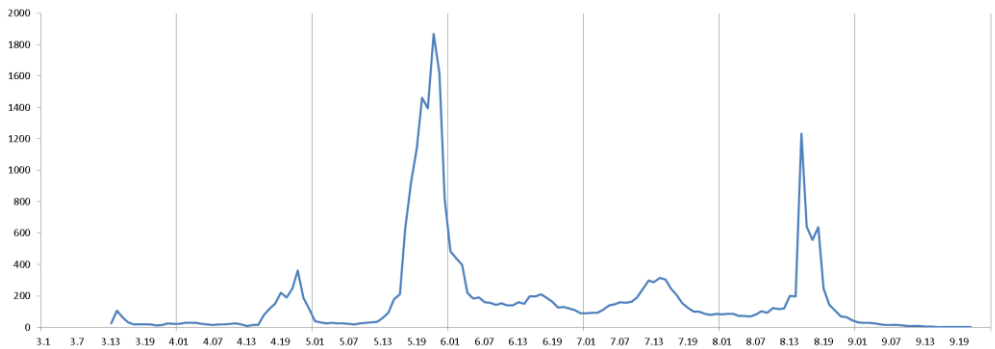


Figure 16. The rate of expansion of the area of the fire (in hectares per hour) from August 3rd to 9th. Note the rapid increase in the size of the burnt area at the end of 5th and during the early afternoon of the 8th of August.

The time tracking in Figure 15 and the graph in Figure 16 show that, every day, there were periods when the growth of the fire was very limited, from midnight to dawn, with easier firefighting conditions between 22:00H and 10:00H, (except overnight from August 5th to 6th). Photographs and videos to which the Observatory had access also show this daily pattern of stop-start. Note that the fire was described on the relevant records as with “no active flame across the perimeter” on August 4th at 13:40H, and with “95% of the perimeter without flames” during the early morning of the 6th, which is consistent with what can be seen in Figure 16.

3.3.2 Determining factors

Weather and vegetation conditions were clearly key to the growth of the Monchique fire, given the combination of strong winds (with daily highs consistently over 30km/h) low humidity relative to the air and to the dry leaf compost, (about 7% from the beginning, which only increased from the night of August 6th), and an unobstructed forested area composed of vegetation that was perfect for rapid and intense fires (eucalyptus, scrub, cork oak and plenty of bush growth).

Weather conditions during the fire period are illustrated in Figure 17, which shows the increase in temperature, relative humidity and wind at the Foia observatory station, and the hourly fire hazard index (FWI) for the area where the fire was active.

Figure 17. Meteorological, temperature, relative humidity, and wind figures at 10m from the Foia (IPMA) observatory station, with Meteorological Hazard Index (ISI and FWI) calculated at 10 minute intervals.

Of particular note is the fact that the maximum growth period of the fire at the end of August 5th coincided with a sharp increase in wind speed at Foia (which peaked at 40 km/h) and a very high FWI reading during this period. This growth of the fire is followed by a pronounced drop early on the 6th, in what we have already called the "window of opportunity" (Figure 17). More generally, land topography and air currents were the driving factors in fire growth during the mornings, and wind was the driving factor during the afternoons, with significant activity concerning projection generating secondary outbreaks as far as 0.5 to 1 km away.

As well as weather, it is important to consider vegetation. An analysis of the growth of the fire on an hourly basis as the trees were burnt allows us to look at the factors that affected its spread. The analysis explained 88% of the observed variations, with wind speed being the main factor (53%), followed by the humidity level of the dead vegetation (28%), which is very strongly linked to relative humidity. Also relevant was the type of vegetation involved (19%).

Although vegetation is only a minor factor in the fire's propagation, an hour-by-hour analysis of land use in the affected areas gives us food for thought (Figure 18).

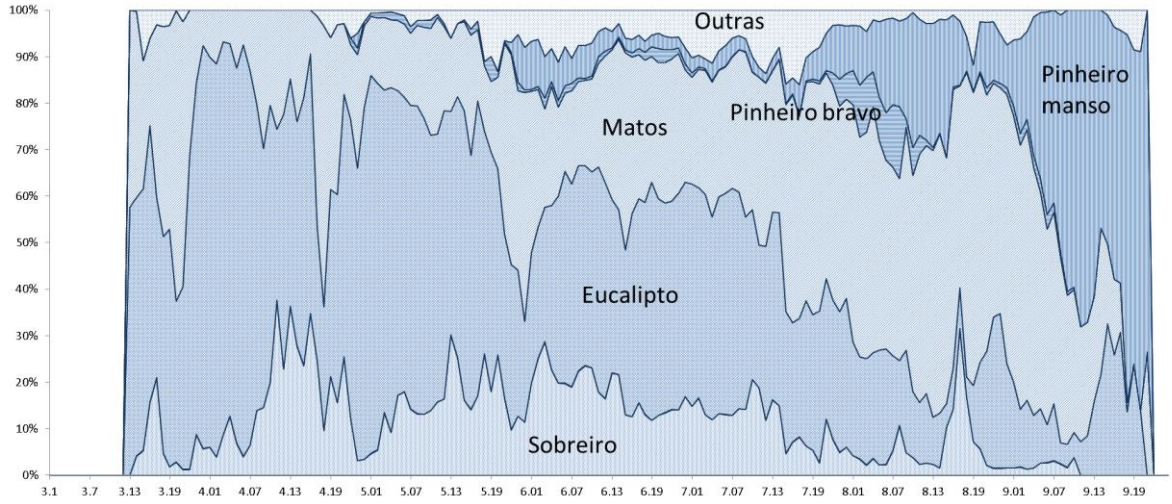


Figure 18. Composition of the areas burnt by percentage.

An analysis of figure 18 shows that in the first two days (August 3th and 4th) the fire was focused mainly on eucalyptus growth (55% of the burnt area) and undergrowth (29%) and the spread of the fire was not very fast, possibly held back by young eucalyptus patches under commercial management.

The fire grew most significantly on August 5th, burning eucalyptus trees in about 50% of the affected area during this time. On the 6th and the 7th of August, the burned area of undergrowth

(41% of the total) gained ground against eucalyptus trees (44%), and on the 8th, the fire destroyed mainly scrubland (70%). On the 9th, as very little of the affected area had other softwoods, the stone/umbrella pine was the predominant plant affected.

The analysis also showed us the link between faster rates of fire growth and higher proportions of bushes and cork oak (which were comprised of a significant amount of arbustus).
The same can be observed by comparing the graphs in Figures 16 and 18.

The growth of the fire both affected and was conditioned by the fire fighting operations described as follows.

3.4 The Initial Attack

"The Initial Attack (ATI) on a new or recently detected fire imposes an obligation on any citizen, because in principle it is easier and more feasible to put out an outbreak of fire when it is in its nascent phase. The main operation comes under the ambit of the Fire Brigade (CB), the GNR, the Forestry Teams (ESF) and teams from commercial companies. Technically, the operation is organised and integrated, underpinned by an initial dispatch of resources up to 2 minutes after the location of the fire has been confirmed, ensuring that there are firefighting measures of some type within 20 minutes of the alert. This approach is based on the concept of triangulation, that is, the dispatch of 3 (VCI) from the three Fire Brigades closest to the site of the fire, taking fast and incisive action from the first few minutes. This action should be backed up by the immediate dispatching of an ATI aircraft and its team of helicopters if the location of the fire is within the operating range of the ATI aircraft, and according to the level of engagement and equipment available which is checked at the time." (Observatory Report 2018).

ATI usage is restricted to a maximum of 90 minutes, the time limit determined for a light aircraft's self-sufficiency. This operation ends when the fire is considered to be under control (put out) by the COS there and then, or at the time the fire status moves up to Extended Attack (ATA).

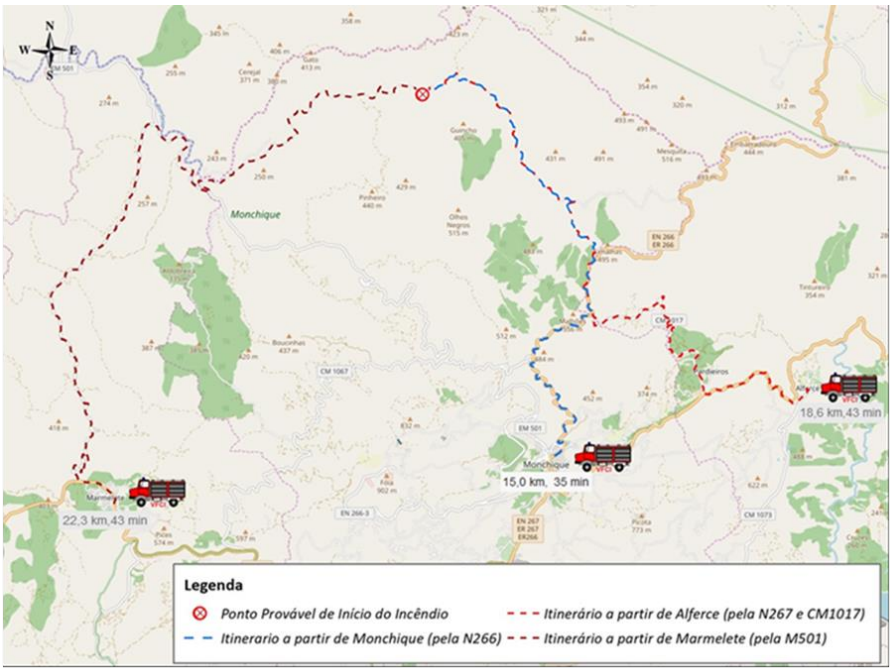
In the case of this fire, the alert was registered at 13:32H on August 3rd. According to the reports from the Faro CDOS Technical-Operational Briefings (BTO), the zone was under alert before it happened, ensuring the pre-positioning of the ECIN H24 (Marmelete), the mobilisation of 25% of the pre-alert staff and the mobilisation of a bulldozer and tractor with trailer in 30 minutes (BTO No. 227/2018), as well as the pre-positioning of ELAC H12 between 08:00 and 20:00H in Marmelete (BTO No.34235/2018). On August 2nd, the Red Alert level was set until 23:59H on August 3rd (BTO No. 237/2018), which requires operating procedures to be put in place as in DON No. 2 and the Algarve Operations Plan, such as active prevention measures and operational planning, in

order to ensure an early and immediate response to possible emergencies. In this operational context, BCIN Barlavento 01 (VCOT, 2 ECIN and ELAC Lagoa) in Alferce (Monchique) and CRANE 02 Lisbon in São Marcos da Serra (Silves) were established, maintaining the methods set out in the previous BTO. Additionally, and in accordance with BTO No. 239/2018, on August 3rd a ELAC of CB Olhão was pre-positioned in Monchique at 09:00H.

At the time of the warning, the first dispatch was sent to the place of the incident: the first COS, the head of the GIPS of the GNR. The dispatch involves an integrated sequence for the methods of fighting the fire. It should be stressed that despite the relatively short distance (about 20 km from the pre-positioning locations), the undulating contours and the type of ground restricted the mobility of the ground based fire combat and the speed of travel was further limited by having to transport water.

The triangulation approach was carried out by three means of combat from three different CB's and a light aircraft (ECINs of CB's from Monchique, Aljezur and Portimão, and H37 and H46 aircraft) having been reinforced from the first moments that the situation turned adverse.

The shortest routes checked on Google Earth Pro are shown on the map and table 1 from the LEPP to the probable starting point of the fire, giving the corresponding distances. Given the characteristics of the forest road network, where average vehicle speeds are approximately 25 to 30 km/h, this results in approximate arrival times at the probable place of the incident.



LOCAL ESTRATÉGICO DE PRÉ-POSICIONAMENTO	EQUIPAS	DISTÂNCIA APROXIMADA ATÉ AO LOCAL DE IGNIÇÃO (km)	TEMPO APROXIMADO ATÉ AO LOCAL DA OCORRÊNCIA (minutos)
Monchique	CB MONCHIQUE	15,0	35
Alferce	BCIN Barlavento 01 (VCOT, 2 ECIN e ELAC Lagoa)	18,6	43
Marmelete	ECIN H24; ELAC H12	22,3	43

Table 1. Routes plotted from LEPP to the likely point where fire started giving approximate distances and times. Source: Google Earth Pro; Open Street Map.

At six minutes, there are reinforcements with AFOCELCA aircraft and a reconnaissance team (ERAS). At eight minutes, two Fire Boss amphibious aircraft are dispatched with Alfa 08 and Alfa 09. The Lisbon Extended Attack Group (CRANE) of the Lisbon Fire Brigade, pre-positioned in São Marcosda Serra, is mobilised. At twelve minutes, a heavy Kamov (H73) helicopter is put into action. At twelve minutes, six brigades from the district of Faro and one new GRUATA, Lisboa 02, pre-positioned in Ourique, are sent into action.

Even though the mobilisation level of the ITA phase was exceptional, this did not translate into objective results when you look at the growth of the fire. The first team to reach the TO was the H37 Pilot Commander and helicopter operatives, who reported that the fire had already affected a very significant area.

Between the time of alert and the dispatch of resources, the operation of dispatching these resources was swiftly carried out within two minutes. The 20 minute limit for the arrival of the first firefighting resource was also accomplished, through ATI aircraft. As already indicated, the travel time from Monchique and from the LEPP to the start of the fire could never be less than

30 minutes, especially with heavy land vehicles. The time that the fire started remains to be discovered, but with one photograph showing a plume of smoke at 13:34H, it could not have started much earlier than this. As mentioned elsewhere in this document, weather conditions were extremely hazardous in terms of fires, characterised by extreme fire behaviour on steep slopes. For this reason, the fire rapidly increased in size (Figure 19).

Figure 19. Photographs of the development of the early phase of the fire from various points (coordinates 37.40 ° N;8.48 ° W, the two top photographs and 37.40 ° N; 8.55 ° W at the bottom two). Source: AFOCELCA.

The 2nd Commander of Monchique Fire Brigade, who is on his way to the TO, issues the following request: "… situation is complicated and increased resources are needed for the TO…". The head of the helicopter team said in his first briefing (POSIT): "… high intensity eucalyptus

and bush fire, steep slopes, more resources needed here". It took about 10 minutes from the alert to the operatives' messages, which we would estimate would take another 20 minutes to reach the site. On the other hand, the time lapse from the statement from the helicopter team to the estimated start time was around 25-30 minutes, which suggests that the fire would have completed its accelerated initial phase and would therefore already be beyond extinguishing given the weather conditions there.

3.5 The Extended Attack

"If, after 90 minutes after dispatching the first ATI resource, the fire has not been reported as under control (or put out) by the Relief Operations Commander, the extended attack must be put into operation without fail. The ATA operation could even start before the first 90 minutes are up, when the COS forecast of the growth of the fire determines that it is necessary. " (Report Observatory 2018).

Operationally, the Perna da Negra fire in Monchique went on to the ATA phase at 15:02H on August 3rd 2018. In "Initial comments on the Monchique Fire" prepared by the Faro District Operational Commander, a significant amount of resources were requested time and again from the National Command, all of which were fully responded to with four Forest Fire Reinforcement Groups (GRIF), a convoy of bulldozers, GIPS and FEB groups and military platoons. Preparation and dispatch of resources was made easier by the absence of other serious fires in the country at that time, which allowed the maximum mobilisation of the various resources.

The major mobilisation of reinforcement resources at this stage of the ATA (heavy aircraft and reinforcement groups) was made possible by balancing out the rescue and ground support resources between districts, for dispatch by the CDOS and/or interdistrict land and air nationals by order of the CNOS. There was also cooperation from other national and international organisations or institutions, and the bilateral agreement with Spain, which allowed the mobilisation of three Canadair heavy aircraft.

Between 23:00H on August 3rd and 08:30H on August 4th, the area affected by fire grew from 325 ha with a 9 km perimeter to 535 ha and a 12 km perimeter. Now that weather conditions were less critical and a substantial range of firefighting resources were available, the fire was very close to being under control on the morning of August 4th. This was the first lost opportunity to get it under control . The window of opportunity remained open until 12:00H on August 4th, but the lines of control were not "closed" and/or properly monitored. Difficulties may have arisen as mountainous terrain limited the efficacy of operational decisions.

However, the report from the District Operational Commander states "… at times, some teams and groups had the wrong attitude, and were not very proactive, including failing to do follow up work by putting out the fire when asked to do so." This theme will be further developed when we look at the specific issue of the aftermath.

On August 5th, the northern fire zone was secured and a strategy was set out to bring it under control over the night of August 5th/6th. To this end, additional resources were sought to ensure operations with more physical presence, including six more GRIF, bulldozers, FEB and GIPS. During the afternoon, weather conditions worsened, but the strategic plan was put into action as planned. Nevertheless, the ability to anticipate necessary resources was lacking, and there was an aggressive and rapid spread of fire up to the EN 266 road, which was the control line, and in a few hours it reached the village of Alferce. The fire entered the town of Monchique early in the night, which needed additional back-up resources for the perimeter defence.

On the morning of 6th, the expanded attack strategy finally seemed to bear fruit. It was noted that "…there are no active fires on 95% of the perimeter , but there are many hotspots which are more than ready to re-ignite, and there is little chance of fighting this, as they can occur in areas that are inaccessible to ground-based resources, and air forces are limited in their usefulness. This will not enable us to slow down the progression of the fire so as to organise ground-based resources. " At this stage of the fire, the chances of edges re-igniting seem to have been underestimated, considering that 5% of the perimeter was still out of control, or roughly 4 km. So it would appear that another opportunity to control the fire was missed. On the afternoon of the 6th, several plumes of smoke could already be seen (Figure 20).

Figure 20. Photograph showing part of the perimeter of the fire, where numerous smoke columns are observed on August 6th at 15:26H. Source: AFOCELCA.

It should be noted that georeferenced perimeter surveys of the fire are not normally done as part of REVIS, as was the case in this fire. Also atypical is analysis of the individual active fronts of the fire, to get an idea of the potential behaviour of the fire as well as working out the amount of and type of resources required for the perimeter. In these situations, as a rule, if there are no working maps with properly marked out perimeters which set out the various operations involved in putting out the fire, this results in a greater risk of accidents and problems in putting the firefighting strategy and tactics into effect.

Figure 21. Photograph, August 7th at 9:30H, with countless plumes of smoke next to extensive areas that had not yet burned, yet there were no firefighting resources in this zone. Source:AFOCELCA.

On August 6th, at 23:50H, the National Command took over operational command (under the charge of the second National Operational Commander), formalised on August 7th at 18:26H.

From the morning of August 8th, the main objective was to contain the fire within the agreed area, to the east up to the IC1 road, to the south up to the EN124 road, and to the west in the Foia area. Recovery of the TO organisation was started on 8th and 9th, still with operational activity at a high level, and the fire was officially under control on August 10th at 7:55H.

Once again, we highlight the Faro District Operational Commander's preliminary report, where the plus points, areas of improvement, and conclusions are mentioned, which we essentially agree with. Having already mentioned the failure to bring critical stretches of the boundary of the fire under control, we quote the following from that report: "… although they have training and adequate equipment, it was noted that military members of the platoons tended not spend time carrying out follow up work. They were more interested in limiting their work to surveillance. " In the same vein, in point 3, paragraph (n) of the National Relief Operations Commander's preliminary report under areas of improvement, it is noted that they should aim to: "make the military platoons aware of the need to work with hand tools" .

This passive lack of initiative may have been caused by fear and lack of experience in complex fire situations, but this should not be applied generally to all operatives involved. When it becomes impossible to extinguish the front of a fire, it makes sense to wait for the fire to change, whilst

continuing to work on the sections of the perimeter that are possible to put out, or that need hard manual work to extinguish.

Figure 22 shows roughly the number of operatives available, compared with the growth of the fire perimeter day by day, from August 3rd to 9th. Based on data relating to the "Notification" of the COS and recorded in Incident Report 2018080033743, for the entire fire there was an estimated average of 26 operatives per kilometer of fire perimeter. This is a figure that exceeds any of the 100 fires over 2500 ha included in a study carried out from 1998-2013 (Fernandes et al.2016).

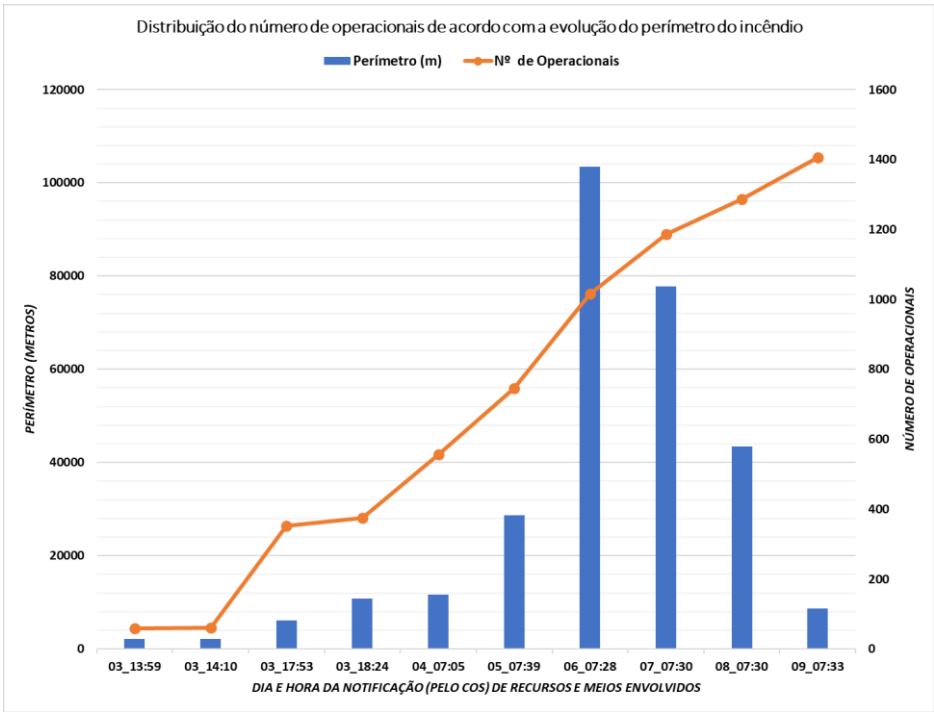


Figure 22. Distribution of operatives compared with growth of fire perimeter between August 3rd and 9th 2018.
Source: Incidente Report 2018080033743 - Monchique Fire – ANPC

The firefighting plan should be implemented according to resources, and the capacity available, in order to achieve the objectives within a certain time and space, and avoid a reactive response to the fire, as happened in various instances in this fire. Of no less importance is ensuring that military surveillance isn't just a matter of observation. It should be made compulsory for the control lines to be covered on foot and for hand tools and water to be available to prevent fires relighting.

In the following sections, we cover the various means and approaches under the concept of Extended Attack, focusing on air resources, fire suppression and bulldozers.

3.5.1 The air forces

We have here a fire with an estimated burnt area of more than 27,000 ha. Dealing with this incident involved 3,005 operatives, 855 ground based resources and 28 air resources. There was a substantial allocation of air resources to the Monchique fire, which was only possible because there were no significant incidents in the rest of the country. The district of Faro was fully covered by the first involvement of aerial resources. In addition, a pair of Fire Boss aircraft were available to make a further contribution during the ATI phase.

There were various types of air assets mobilised for this fire: helicopters and aeroplanes. For rotary wings, there were the light helicopters, committed to ATI from the start, medium helicopters and heavy duty Kamov helicopters. Aircraft available included the Fire Boss used in ATI and ATA waiting for pre-positioning in Portimão, and Canadair heavy aircraft available for use anywhere in the country, as well as three Spanish Canadair, implemented under the bilateral agreement between the two countries. They were in permanent operation between August 7th and 9th.

On many occasions, weather conditions hampered the effective use of air resources due to the force and turbulence of the wind and the lack of cover due to smoke in difficult terrain, which often gave rise to safety factors cancelling the work. This situation worsened in the morning. Air resources would have been more effective then, but the inverse thermal conditions in the lower atmosphere kept the fire smoldering and prevented aerial support.

It should be noted that the Portimão runway is listed in DON No. 2 as an alternative airfield (CMA). This explains why the aeroplanes had to give up refuelling in Portimão, claiming unsuitable conditions, and had to refuel instead at the air base in Beja. This had several consequences, from less autonomy for the TO to an impact on turnover, preventing the optimal usage of scarce and high cost resources.

The use of aerial resources without ground support teams is not at all efficient. In future, protocols need to be changed and ground or air transport teams need to be integrated to support aerial resources, because fires are put out by firefighters on the ground. (Fernandes et al.2016).

3.5.2 The use of fire suppression

If done well, suppression using fire can be a very powerful tool. The timeline of the fire provided by ANEPC refers to the use of suppression by fire by FEB teams (EAUF, ERAS or CRANE) at various times throughout its duration. With one exception (at 16:46H on August 8th), controlled burn manoeuvres all happened at dawn and early in the morning on August 4th, 5th, 8th and 9th, in safer conditions.

It is not possible to evaluate the impact of maneuvers concerning fire containment and extinguishment except in two cases mentioned in the UAEF intervention reports, which detail the modus operandi of the manoeuvre and describe the outcome:

1. On August 4th (1:50H), a counter-fire near Aderneira, in order to facilitate the extinction of a secondary outbreak and contain the spread of fire to one side of a road. The manoeuvre was made along a length of 266 m and was successful.

2. On August 8th (17:00H), a tactical fire in the immediate vicinity of the Arade reservoir to safeguard two dwellings. The controlled burn was done over a 190 m stretch with a positive outcome.

On August 9th (7:00H), there is mention of a tactical fire between Talurdo and the Funchal reservoir, validated by the COS, but not carried out because permission was not given by the front commander.

Dia	Hora	Descrição	Nota
04/08/2018	01:50	COS informs the EAUF FEB team that a “controlled fire” will be carried out in Sector Alpha to ensure safe conditions for the operatives. STARTING COORDINATES: 37 ° 22.349’N | 8 ° 35,660’W;END COORDINATES: 37 ° 22.265’N | 8 ° 35,580’W	Reported in EAUF03 FEB. Maneuver successful.
04/08/2018	01:59	“Controlled fire” operations by the EAUF FEB team successfully carried out in the Alpha sector	
05/08/2018	03:10	PCO was informed that tactical fire was carried out by EAUF 01 FEB starting at 03:10 at the coordinates 37 ° 21.4934N | 08 ° 33.1554W and ending at 04:30 at the coordinates 37 ° 21.4072’N and 08 ° 33.5609’W	No report was obtained
05/08/2018	08:34	CMDT Delta sector authorisation requested to use “Controlled Fire” by the ERAS FEB team. COS authorises “controlled fire” manoeuvre.	No report was obtained
05/08/2018	09:14	CMDT Charlie sector asks for permission to use “controlled fire” from GRAUTA FEB. COS authorises the manoeuvre.	No report was obtained
08/08/2018	04:57	FEB proceeds to tactical fire at coordinates N37 ° 21.2292’NW08 ° 35.5774’W	No report was obtained
08/08/2018	13:34	GNR informs individual PCO to pull the fire into	No report was

		Barão de São João area.	obtained
08/08/2018	16:46	EAUF 03 info PCO fire suppression manoeuvre near Arade reservoir to try to divert fire from houses | HI 16:44 -37 ° 14,3420'N | 08 ° 26,4537'W	EAUF03 FEB Report. Manoeuvre successful
09/08/2018	00:42	CDOS Faro / PCO: reports a fire alert in the Talurdo locality, asks if EAUF is still doing fire manoeuvres there. PCO info MR on site / EAUF FEB / ICNFCa	says in the EAUF03 FEB report that the manoeuvre was approved by the COS but overridden by the front commander who disagreed.
09/08/2018	08:48	Dispatch 08:50H, fire suppression to be supervised by Delta-Bugado Sector Commander, Silves.	

Table 2. Records show the use of fire between August 3rd and 13th, 2018. Source: Incident Report 2018080033743 - Monchique Fire - ANPC. Own Preparation: Observatory Independent Technician, 2019

There is also mention of the use of a controlled burn, probably by members of the public, in the Barão de São Joao area, identified by the GNR and communicated to the Command Post, but we have no more information on that.

When asked by the OTI about the use of fire (February 27, 2019, Silves), CODIS of Faro, Commander Vaz Pinto said many operatives performed controlled burn manoeuvres without the knowledge and authorisation of the COS and that what they did was poorly done. It was also noted that there is no specific map or strategic plan in the focus area of operations for the fire suppression manoeuvre, and further stated that this type of maneuver should be done during the day and never at night.

Overall, and as far as we can conclude from the available information, fire suppression operations had a very reduced impact on the course of the fire.

Certainly, the scrubland areas of the affected land, which are mainly esteva (Cistus ladanifer), have a very short time limit for the safe and effective usage of fire suppression methods. Throughout the afternoon, they burnt with great intensity. Conversely, the spread of fire can be impeded at night with the increase in relative humidity.

In fires on hilly ground, fire spread is essentially controlled by the slopes and the rough terrain, the exposed hillsides and the local winds. In other words, the fire's intensity and direction change throughout the day, with predictable "flare-ups", which allow the potential for spread to be checked early on. Therefore, the use of tactical fire and counterfire can be crucial in limiting spread. According to the information recorded, its use was limited, probably due to lack of familiarity within

the COS with the AA technique, since the use of fire suppression is not common practice in the territory as it is in other parts of the country.

On the other hand, decisions about the use of fire must work within the window of opportunity, or the “etiqueta horária”. Such a decision cannot and should not depend on the opinions of those with responsibilities in the chain of command that make up the SGO, as decision-making is the sole responsibility of the COS, as stated in Article 16 of Order no.7511/2014, of June 9th, which approves the Technical Fire Regulations.

3.5.3 The use of bulldozers

Bulldozers are needed for work on the edge of the fire – during this fire, there were a lot of them deployed (26 units). They should work together with the land-based firefighters with hand tools. This did not happen, and there are numerous photographic records showing this operational failure – a frequent occurrence in large forest fires in Portugal. Additionally, putting out fires with bulldozers has practical limitations and calls for drivers experienced in forest fires. Figure 23: some situations showing poor use of bulldozers.

Figure 23. a) Hot spot in green area (not yet burnt) with bulldozers dragging combustible material through openings in the line of defence; b) Part of the affected area (still burning) on the left side of the photo was on the outside of the line of defence opened by the bulldozer; c) Line of defence opened with bulldozers is broken through twice to dump burnt material outside the line. Source: AFOCELCA.

We also found, during the visit to Monchique and Silves and at the meetings held there, that many bulldozers often worked without the support of firefighting equipment and personnel able to supervise the work. In various parts of the fire they were available, but not active, and some never worked, either through their own fault, lack of fuel or just because they weren't being assigned the jobs.

Based on the AFOCELCA report on this fire and what the ATA says, in alignment with many other reports, the deployment of the bulldozers failed in establishing a strategy for organised combat, alongside other ground-based resources or with those in the air.

3.6. Aftermath, reactivation and re-ignition operations

Working with the aftermath of the fire can cause problems with fire reactivation, and re-ignition. These phenomena are similar but have different definitions.
The National Operational Directive 2 (DON2) clarifies that while reactivation refers to an "increased intensity of part or all of the perimeter of a fire during the aftermath operations and before it is deemed by the COS to be ashes", re-ignition is defined as "a new occurrence that begins at the perimeter of the area affected by a fire that was thought to be extinguished (after completion and monitoring work is finished). In other words, this occurs when all resources have gone from the centre of operations. The burnt areas where these incidents occur have to be classified under the relevant cause type 'rekindle' and cause 711 - 'heat source from previous fire'."

As stated in the previous sections, there have been several missed opportunities when the fire appeared to be under control, and when the post-fire works of consolidation would have been the deciding factors.

We are referring in particular to the "windows of opportunity" between the night of 3rd and the morning of 4th, when the fire was almost out, the night of 4th/5th and the dawn of August 6th, when the weather was better. In this section, we will detail the facts of the night and morning of the 3rd/4th of August, when the fire was virtually extinguished, when the fire and its perimeter were still insignificant, (compared with the size at the end of the fire) and when the post-fire works of consolidation could have made a huge difference.

According to various sources consulted (ANPC and AFOCELCA), the fire was practically out by the end of the morning of 4th, following around 20 hours of activity. From an analysis of the fire by NAD-AIR at 2:40H on August 4th, various recommendations were made on the incident (Operational Information No. 2) on ANPC occurrence. They refer in particular to the need to make

the most of the night time window of opportunity (inverse thermal dynamics), to skirt the entire perimeter of the fire, preferably using bulldozers, supported by ground resources and manual equipment, and to scorch all of the perimeter fringes to separate the combustible areas.

According to the AFOCELCA report, by late morning on the 4th there were four critical points: two to the north and west under the charge of AFOCELCA and two to the south and east under ANPC. It is precisely those last two points that reactivated around 14:30H, starting off the second phase of the fire that then spread to the south/south-east. Everything became more complex from here. It seems that none of the recommendations made by NAD-AIR to extinguish all combustible hotspots were followed, and the fire reactivated at the hottest time of day. This Observatory has not come upon any detailed information on what could have happened for there not to have been a complete extinction of the fire at these two critical points. However, various information suggests that the performance of the teams in these areas was not the best for ensuring the fire was completely extinguished. The places are not even accessible by bulldozers as they are in steeply sloping areas, so that at the very least, manual equipment would have been needed in these cases. But we are not aware of any efforts being made in this regard. Nor, we should add, are we aware of the practical feasibility of this type of operation in these places. In any case, everything suggests that there would have been operational constraints that would have allowed the fire to reactivate at a time when all combustible hotspots should have been put out.

There are several references in the documents we have read to shortcomings in the post-fire and consolidation works. For example, under 'areas for improvement' in the preliminary report of CODIS Faro, Commander Vaz Pinto states on 20th August: "At times, some teams and groups had the wrong attitude, and were not very proactive, failing to do follow up work to put out the fire when asked to do so" and that "poor safety conditions are often used as an excuse by firefighters when they don't want to do a manoeuvre that they have been assigned to do."

Also in the AFOCELCA report, it is stated that there was no technical and operational support in place to control the fire on the evening/night of Friday August 3rd, and, in addition, that the fire was not put out on the morning of Saturday August 4th, when there were good weather conditions for doing so and strategic points for an easy resolution had been identified in good time. On the other hand, the same report refers to deficiencies, also highlighted by the ANPC, regarding the need for technical supervision of the work of the bulldozers in order to coordinate this with other resources like manual equipment, water and specialised use of fire suppression. Still, in the same

report, a reference is made to deficiencies in surveillance. It should be noted that such important jobs need to be carried out rigorously and carefully, with a proactive and responsible attitude, keeping potential future reactivations in mind.

Although, on an operational level, there are no details that will allow us to see what happened to prevent windows of opportunity from being used (particularly concerning what happened at dawn on Saturday 4th), everything suggests that despite the huge amount of equipment assembled on the ground, effective use was not made of these resources.

It's important for us to highlight some conclusions and recommendations from this analysis. Firstly, there is a high number of reactivations from shortcomings happening post-extinguishment. This is consistent with the very high number of re-ignitions in forest fires in Portugal - a problem that has already been identified at least since the USA - Portugal Technical Cooperation Project on Forest Fires in 2004, which identified a major systemic failure in firefighting.

Despite setting up the PNDFCI with the goal of reducing the percentage of re-ignitions to less than 1%, official fire statistics are still very far from this, and in several years the figures are around or exceeding 10%.

In the specific case of the Monchique fire (Incident Report 2018080033743), between August 4th and 13th, there were 93 reactivations, the most important ones occurring between August 4th and 9th. In terms of percentages, the vast majority (about 56%) of reactivations took place between 12:00 and 18:00H, coinciding with the most favourable weather conditions for an increase in the intensity of the fire (following an increase in temperature, decrease in relative humidity and increase in wind speed).

One reason often cited for a lack of time spent on follow-up work is that several fires need to be attended to at the same time. This is a fair point at times, and in areas where there is an extremely high number of simultaneous occurrences. But in the case of Monchique this was definitely not the case as resources hadn't been spread out to multiple incidents.

The basic reasons for these operational shortcomings lie in long-term deficiencies already identified: most of the firefighters' reluctance to work with manual tools; the lack of preventive measures; classifying the fire as resolved when all combustible hotspots are eliminated, whether or not there are flames left; the lack of initiative by firefighters to get on and sort out a problem in the place they are working.

Faced with these limitations, there's no planning, no tactics, and no manual labour that can solve the problem. Often, the difference between a fire of only 620 ha and one of 27,000 ha (as in this case) is decided there and then when a person or a group doesn't 'own' a problem that they are entirely responsible for.

Solving the problem then inevitably gets passed up the chain to a higher level of specialisation and responsibility in the forces working there. Manual work with hand tools should be encouraged and made mandatory in all situations where this technique is right, particularly in follow-up operations. Follow-up operations must be carried out by fresh teams in sufficient numbers to cover the fire perimeter, and they should have full responsibility with one of them in charge. These teams should not intervene in the firefighting, but work solely on the challenging follow-up work.

The post-fire consolidating work should be carried out during the least favorable time period for fire spread, and should take into account of the time of day (position of the sun), and prioritise operations where there's a chance of re-ignition, looking at the amount of combustible material, the dew point, solar exposure and changes in the wind.

The question of accountability is absolutely fundamental. For every part of the burnt area considered critical, there should be a clear identification of who is responsible for follow-up and post-fire work.

3.7 Public safety

During this fire, public safety was a fundamental concern in an effort to avoid the repetition, albeit to a lesser extent, of the 2017 tragedies. To this end, authorities took the option of removing people from the route of the fire through a massive evacuation programme.

The GNR Report (2018) gives a table listing evacuations from Monchique and Silves between August 3rd and 8th.

Figure 24 shows the places evacuated by GNR on each of the days.

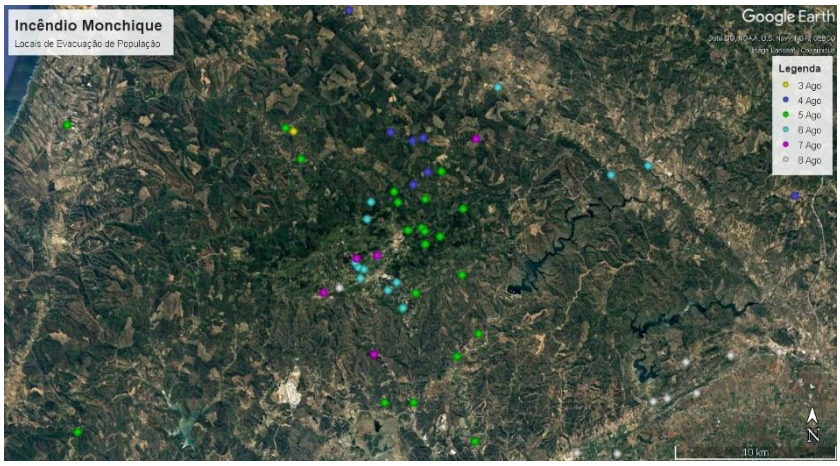


Figure 24. Map of the places where the population was evacuated on each of the days marked in the caption.

Table 3 shows the number of places and people involved on each of the days.

Dia	Lugares	Pessoas
3	1	13
4	10	59
5	27	76
6	15	383
7	10	67
8	12	10
TOTAL	**75**	**608**

Table 3. Number of places and people evacuated by the GNR between the 3rd and the 8th of August during the Monchique fire. Source: GNR.

There was a high number of people taken away on the 6th, as the work involved places like the hotel in Caldas de Monchique and other locations threatened by the fire. On the 8th, unless there were any mistakes made in the GNR report, there must have been places where they didn't manage to evacuate people.

This decision had a successful outcome, as it effectively managed to preserve people's lives, with no fatalities either amongst firefighters or the general public.

This positive result cannot hide the need for a more thorough reflection on evacuations in terms of their appropriateness, their necessity, and the ways in which they are carried out.

We were aware that the decision to evacuate the village of Alferce had to be changed, because the population was relatively safe staying put thanks to preventive work that was done, besides which it was agreed that the intended escape route was no good. The same thing happened in Marmelete, where an evacuation was also planned and should have taken place at dawn, but which eventually did not materialise.

In the GNR evacuation, according to a resident in a property in the Foia area, it was not always possible to ensure adequate accompaniment along the evacuation routes. On August 6th, at 14.00H, GNR arrived at the property to say that they had to leave and go to Monchique or Portimão. On the way there, they met military GNR personnel on the Monchique road, but they went in the Portimão direction. In Nave, the GNR told them to go to Marmelete, but from there on they didn't find any more military personnel on the road. Because they knew that there was a road to Portimão in Casais, they headed along that road to Ferragudo. From this account, you can see that if these people didn't know the area well, they might not have known where they were going and ended up going back to a fire area.

Another lesser-known aspect of the fire, which may seem like a minor issue, was to do with the protection of domestic animals, both pets and livestock. For many people, this was a major worry, either because they were affected personally or economically. It should certainly be a matter of social concern, especially for the authorities, whether at the prevention and intervention stages, or during the recovery phase. There are several examples of cases where citizens risked their lives, or even lost their lives, to try to save a pet or a herd of goats, sheep or other animals, some of which were reported in Viegas et al. (2019).

There is also a growing concern in society for animal welfare, often with organised groups committed to this cause. Concerning the Monchique fire, we obtained a report by a member of the public that described the initiative of a citizens' group who got together in Portimão from the morning of August 6th to go to the fire area to "save as many animals as possible from the flames ". They got going on August 7th in the Alferce area, in conjunction with the Command Post and Civil Protection Authorities. Although the volunteers were poorly prepared and had little equipment, they did a good job helping animals, setting up an animal field hospital and mobilising four teams of volunteers - totalling 55 people - to cover the area during the day in search of injured, lost or even dead animals. The support provided was welcomed by the locals with comments that, in some places, "help would have arrived for animals before it came for people. "

This aspect of animal protection is perhaps an overlooked area in emergency services, so lessons could be learnt from the initiative described above.

3.8 Organisation, operational planning and strategy

3.8.1 The operational briefings

A forest fire can become chaotic and very complex, especially if it gets progressively bigger. The momentum will build up along the extent of the perimeter and the active fronts, affected by various factors that influence the behaviours of the fire. Given the complexity of large forest fires, it is important to understand this and develop an adequate plan and communicate this so that it can be put into action.

One of the key factors in communicating and directing a Strategic Action Plan for the extinction of a forest fire is operational briefing. Operational briefings are necessary and essential in the major fields of operation when putting out fires gets more complex, when there are changes in the behaviour of the fire, exposed elements, and changes in strategy, tactics and resources.

Operational briefing is a brief meeting with those responsible for each command cell and at the various levels of the Operations Management System (SGO), with the aim of ground-level implementation of the Strategic Action Plan for putting out the forest fire, based on the the means and resources available, taking into consideration what the fire is doing now and what may happen in the near future. Likewise, these briefings serve to reassess and finetune the work being done where appropriate.

To this end, Order 3317-A / 2018, of April 3rd (which reviews the system of Operational Management (SGO)) establishes through Article 46 the need to have operational briefings under the expertise and responsibility of the Commander of Operations and Rescue:
“In order to ensure a permanent flow of credible and synchronised information between all those in charge of the SGO, regular briefings should be promoted by the COS according to the complexity and nature of the TO, in order for strategic objectives as defined by the ongoing operations to be checked, and thus contributing to effective command and control.”

An analysis of Incident Report 2018080033743 on the first 10 days of the Monchique fire saw that 25 operational briefings were held, but very irregularly. This data is important, because it shows how the coordination of fire extinguishment work is based on the complexity of the fire, or the way

the command assesses this complexity, and the risk potential, putting into operation and moving resources around in the field of operations.

Based on the spatial analysis of fire spread, it can be seen that in the first five days the fire got through about 77% of its total area, and had reached its final area on the seventh day (08/09/2018). The only work in the remaining days was to do with post-fire consolidation, which lasted about 2/3 of the time that it took to extinguish the fire.

Looking at the data on the operational briefings registered in Incident Report 2018080033743, it appears that on the days when the fire grew the most, only five briefings were held, showing that the forces involved did not follow a strategic action plan co-ordinated by the COS. This implies that combat units present acted without a plan and without the necessary coordination that was required to ensure that objectives were achieved. This in turn led to problems for each team in fulfilling the mission. The small number of briefings recorded and, in particular, the absence of briefings between 9:30H on August 5th and 10:30H on August 7th shows that the Operations Command underestimated the potential of the fire.

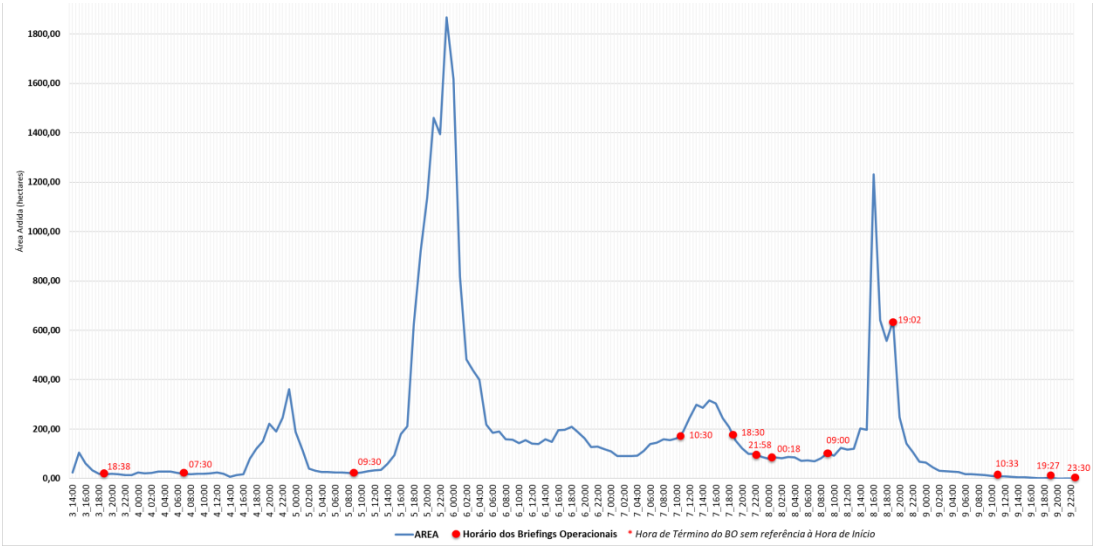


Figure 25. Distribution of the number of operational briefings during the fire compared to the rate of fire growth.
Source: Incident Report 2018080033743 - Monchique Fire - ANPC.

As Figure 25 shows, the vast majority of briefings were performed at a time coinciding with a reversal in fire behaviour, normally in the direction of lower intensity, in the morning hours between 7:00H and 10:00H and dusk and dawn, 19:00H and 06:00H. Of the 25 briefings held, 76% occur at the best times for working on putting the fire out, when fire yields more easily to attempts to

control it. So, sector commanders and managers were forced to leave their work posts during this window at times when they should have been focusing on their various objectives, whether that was perimeter control, manual work on post-fire jobs, or control and operational assessment.

3.8.2 Decision Support

In the municipality of Monchique, when weather conditions are conducive to fire, decision support for the pre-positioning of fire prevention and combat resources is essential and has already been dealt with in the previous chapter.

After the onset of the incident, concerning a fire with the intensity and speed of the one in Monchique and Silves, firefighting decisions are complex, needing good advance knowledge of the likely behavior of the fire.

In this regard, and given the importance of improving the support system for decision making by using the tools that have since become available, ANPC created a cell or Support Centre for Decision Analysis of Rural Fires (NAD-AIR) under the framework of the National Relief Operations Command. This provided support for the CNOS, which was already operational at the time of the Monchique fire.

This internal structure of ANPC is responsible for creating a new tool, a cross-party MAI platform for integrating geographic information from various other institutions, such as ICNF and IPMA, which might help as decision-making support, overcoming the limitations of the current decision-making support (SADO). This process, which started in 2017, led to the creation of the platform that entered its trial phase in June 2018.

From August 1st to 12th, NAD-AIR produced a daily strategic operational analysis with the aim of potential use nationally for weather forecasting. This included the synoptic situation, the temperature of the wind pattern at different times, atmospheric stability and signs that indicate dangerous conditions. Consideration is also given in this analysis to the potential behavior of the fire during this period, according to the forecasts.

During the period under review, on August 3rd, 6th, 9th and 12th, NAD-AIR also included in its strategic analysis a regional breakdown, with weather information from three stations per zone, together with ignition potential and information on fire behaviour concerning the type of fire likely to occur. The analysis zones seem to have been very well arranged to match the groupings of districts, with five clusters: North (Braga, Bragança, Viana do Castelo, Vila Real and Porto),

Central North (Aveiro, Coimbra, Guarda and Viseu), Central South (Castelo Branco, Leiria, Portalegre and Santarém), South (Beja, Évora, Lisbon and Setúbal), and the Algarve (Faro).

The Monchique fire, which began on August 3rd, was the first time during which the platform was tested for its usefulness in supporting operational decision-making. Lessons learnt from this were important in improving the system.

In the specific context of the Monchique fire, the information produced by NAD-AIR was from constantly updated information from the Fire Brigade Special Force (FEB). At 16:00H on August 3rd, it produced initial information indicating the predictable behavior of the fire, intervention priorities, and safety recommendations. From this, NAD-AIR was producing operational information (INFOP) on the 4th (at 2:40H and17:40H), on the 5th (16:50 and 17:30H), on the 6th (20:30), on the 8th (1:00, 10:00 and 16:10H), and on the 9th (0: 00, 9:00 and 14:15H). On August 7th, NAD-AIR did not produce documentation for this job, as it had already been done by members of the Fire Analysis and Use Team (EAUF) from the FEB alongside the command post (PCO).

In the meantime, information on fire spread reached NAD-AIR via images from the Copernicus European Forest Fire Information System (EFFIS) and, more specifically, from information and images from the aerial reconnoitres made in the presence of EAUF teams. Information on the mobilisation of resources was also obtained through SIRESP-GL. Finally, the analysis of anticipated fire behaviour and the strategy to be adopted was put together by ICNF and AGIF technicians, and included the use of simulated forecasted fire behaviour.

The analysis of the information flows required for decision-making and its application are described in Figure 26.

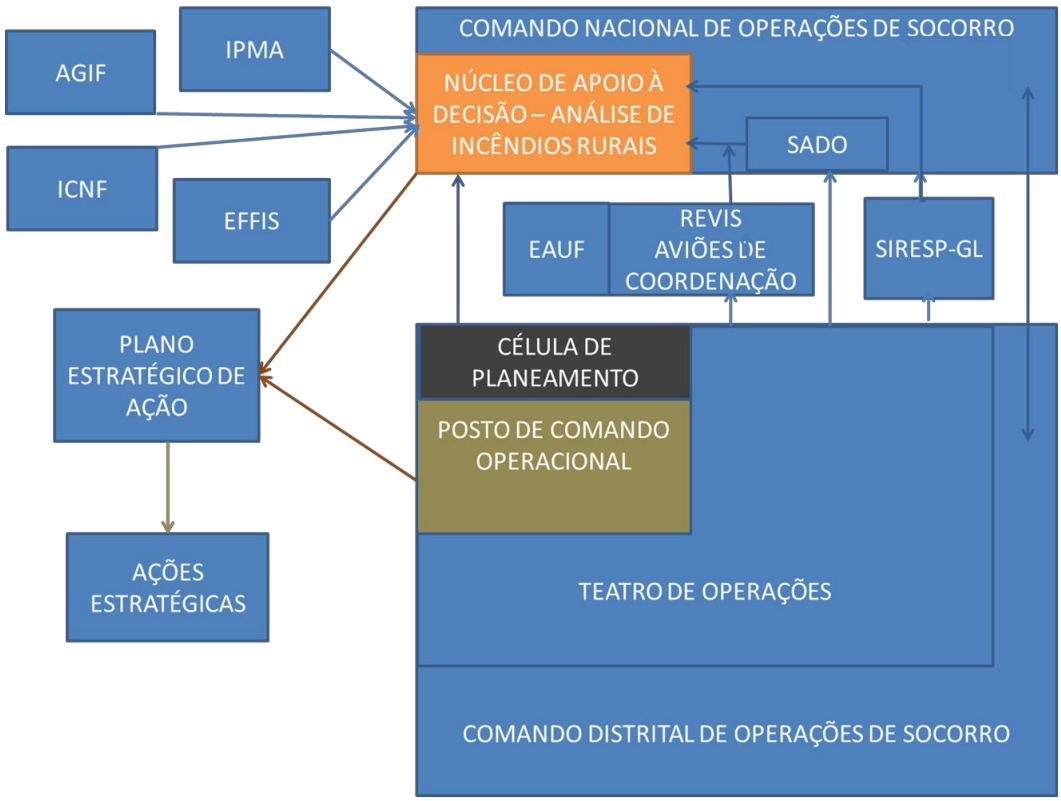


Figure 26. Information flows (blue arrows) and decision-making factors for the Strategic Action Plan (red arrows) which lead to the strategic steps to be taken (grey arrow). NAD-AIR's role in gathering information for decision-making support is absolutely central and key to the whole process of knowledge gathering in firefighting decisions.

This chart highlights the central role of NAD-AIR in collecting various types of place and time-based information on combustible material, weather and fire spread using aircraft and satellites, and on the location of resources. This multiplicity of information calls for careful analysis by various professionals who can use this information and interpret it in the light of existing technical and scientific knowledge as well as their actual professional experience on the ground in crisis management and the management of fires. In fact, in highly complex situations where the main concerns are safety and effective firefighting, good analyses have to be done to make the most of resources.

Looking at the Monchique fire, it has to be concluded that information and analysis were not used enough in the field of operations.

This situation arises simply because of the limited experience of coordination between the operations command and NAD-AIR. This interaction should be considerably improved, tested and prepared a decent amount of time beforehand.

The Observatory considers the initiatives taken by the small NAD-AIR team to be very relevant, in incorporating the most up-to-date information and effective analysis techniques to support

the decision-making process. This work needs to be increased and strengthened, with more resources and training available so that gradually the NAD-AIR core team and associated UAEF regional teams can be given more responsibility.

The Observatory recommends reviewing how Strategic Action Plans are put together. They cannot be just legal, box ticking exercises. Primarily, they need to be simple tools that are continuously updated, so that all those involved know at all times what they are doing and in what context. Later, they can be used in a sensible way to see what lessons can be learnt from the experience.

It is recommended that weather updates are incorporated and sent out more frequently, complementing IPMA information with others as shown in the chart here. Real-time (or near-real) wind information and forecasting should make the most of other weather stations, like those which could be set up on watchtowers and those which already exist on wind generators and are already being used in Alto Minho under collaborative protocols.

It is recommended that AGIF teams are gradually integrated into this working structure in order to contribute to NAD-AIR's technical analysis and complement the work of the EAUF and FEB teams. Finally, it is also recommended that all Operational Commanders have a minimum level of training and instruction on analysis of fires and relevant weather conditions, so that when they are sent technical advice they can swiftly interpret it and use it.

4.The recovery of the burnt area

Rehabilitation of the burnt area is an essential part of the recovery cycle of forest ecosystems. Without this, they could be adversely affected by the serious effects of erosion, floods, etc. and be deprived of the chance to adapt and minimise fire risks. Therefore, immediately following the fire, it is important to be ready to start recovery of the burnt areas.

The costs associated with this recovery are significant. In the National Forestry Strategy Review of 2015, it was estimated that the funding involved in post-fire recovery was around € 1,000 per hectare of burnt area. In the case we are looking at, that would imply costs of around € 16 million.

The approach planned by the ICNF in the post-fire recovery of the affected areas in Monchique followed conventional methodology adopted in the Forest Anti-fire Defence System and in specialised literature (Moreira et al. 2010), which involves three distinct phases: stabilisation, rehabilitation and long-term intervention.

4.1 Planning for emergency stabilisation

Stabilisation should proceed very quickly after an assessment of the damage caused to sensitive areas, with the aim of controlling erosion and protecting the river network. It must also consider the protection of infrastructure and built up areas, as well as surrounding habitats (Independent Technical Observatory 2018).

For large-scale intervention, work such as creating meadows, soil covering using organic waste, soil covering with organic residues and emergency sowing (like 'hydro-seeding', or seeding by plane) should be considered, alongside measures to reinforce water systems and to slow down surface run-off, various eco-tech measures such as bio-coverings, bio-rolls, fibre logs, bundles, etc, anti-flood works, restoration of the river ecosystems and measures to prevent the post-fire spread of exotic species, including acacia and eucalyptus. It's also essential to alter the flow of water courses and their sediment, to stop the destruction of river banks by torrents of debris and the increase in maximum flow levels due to the banks being built up and waterproofed, which requires, amongst other things, restoring sedimentary basins to their proper shape (Gonçalves and Vieira 2013).

In the case of the fire under review, crisis stabilisation was the subject of an assessment drawn up by the ICNF and the Algarve Department of Nature Conservation and Forestry (ICNF 2018), which discussed all "works necessary for stabilising the affected ecosystems and clearing burnt matter, with a view to restoring productivity afterwards, keeping in mind the replacement and

sustainability of the affected ecology". The assessment was drawn up to highlight the financial instruments available (Operation 8.1.4, "Restoration of forestry affected by natural and man-made causes and catastrophic events ", contained in action 8.1," Sustainable Forestry "Measure 8, "Protection and Rehabilitation of Woodland Areas", from the Rural Development Programme for the Portuguese Mainland, PDR 2020) (Ordinance No. 134/2015, 18th May).

The stabilisation measures required were listed by the type of process (Combating erosion and heavy rainfall; Recovery of damaged infrastructures; Control of erosion, treatment and protection of slopes; Prevention of contamination and silting and recovery of water courses; Loss of biodiversity; and Plant protection). In the case of infrastructure, they followed the classification and terminology set out in 134/2015, and, in the case of heavy rainfall treatment and plant protection, they followed a series of generic guidelines that are a normal part of post-fire stabilising reports produced by the ICNF.

They also provided sheets on "Post-fire stabilising work requirements", where they gave detailed information on all recommended measures by giving the number or area, unit cost and total cost of implementing it, using the structure and classification of the measures set out in Ordinance 134/2015, for the entire affected area (Monchique, Silves, Portimão and Odemira municipalities) and individually by county (ICNF 2018). The estimated total cost of the measures was approximately 4.58 million euros (2.73 million euros in Monchique, 1.82 million euros in Silves, 38,500 euros in Portimão and 11,150 euros in Odemira). However, in this ICNF report, no information on the evaluation methodology, nor of cost estimates, nor of priority areas was given.

Putting things into place took time, despite the rapid response through the RDP 2020 (the first applications were welcomed between August 30th and September 30th, 2018, under operation 8.1.4 which prioritised control of erosion, treatment and protection of slopes - and even the restoration of infrastructures - at a sum of 4.5 million euros), previously included in the ICNF report (ICNF 2018) for the four municipalities affected by the Monchique fire (10th announcement, operation 8.1.4, ", "Restoration of forestry affected by natural and man-made causes and catastrophic events ").

In view of the need to get urgent works carried out after the fire, Decree-Law No. 70/2018 and Ordinance No. 237-B / 2018 of 28th August streamlined this work in the municipalities of Monchique, Silves, Odemira and Portimão through the implementation of a unique programme

of public works procurement and the option of advance payment invoicing for emergency stabilisation works (for settlement within 45 working days on receipt of proof of payment of all expenditure). These arrangements were essential because they were used to a great extent in restoring stretches of the primary network, and in the management of combustible material along borders in sections of the secondary network; they also supported water spots, control of erosion, treatment and protection of slopes, prevention of contamination and recovery of water courses.

It is true that some work had already been done, but this was just for demonstration and training purposes, and covered a very limited area. We make a special note of the way burnt wood and chippings were spread over the ground at Herdade da Talhadinha in Silves in mid-December. This also allowed training for the GIPS and foresters in aerial seeding over an area of 150 ha using Dromader aircraft. Under the management of the ICNF, this ensured emergency stabilisation works were carried out in the Herdade da Parra National Forest. However, this last action was only carried out on February 28th, 2019, and on a case-by-case basis, despite the declaration that more major work would be done for the first rainfall of the season, when such work was crucial (much of the soil loss happens in the first winter after the fire). However, none of this work was backed up by funding in the above programme. We do not know of any concrete emergency stabilisation works implemented under this funding programme.

Unfortunately, despite the rapid response from the ICNF (ICNF 2018) and the system of selection set up to deal with issues in Monchique, there is an excessive delay between the fire and the practical allocation of emergency stabilising resources and control of erosion planned. Better technical support by ICNF in defining the measures required - and in mapping the areas for priority work, or those most susceptible to soil loss - as well as in reviewing administrative procedures inherent in these measures could have made a real contribution to faster intervention, better decisions on costings, and above all, more success in the rehabilitation of the area.

Figure 27 . Demonstration work on containment and stabilising works to slopes. Source: ICNF.

4.2 Support for rehabilitation work.

Regarding the rehabilitation phase, “where the response of the ecosystems should be monitored, and natural engineering measures designed to increase infiltration and allow for the consolidation of the slopes and embankments and, eventually start a proper reforestation of the most critical areas ”(Independent Technical Observatory 2018), tenders were invited for “Support for the Rehabilitation of Forest Areas Affected by Fires ”under Operation 8.1.4, “Restoration of forestry affected by natural and man-made causes and catastrophic events ” of the PDR2020 (14th announcement).

Applications could be made between 16th November 2018 and 31st January 2019, and this was open to individuals or groups, public or private, and local authorities, with confirmed levels of funding between 70% and 85% per project for a budget allocation of 4 million euros. The eligible projects were as follows: “work on woodland rehabilitation (except fast-growing species), reforestation of affected areas and repairs to damaged infrastructure (only for the repair of fencing and forestry-related rehabilitation) in areas affected by fires in the forestry sector”.
This process benefitted from previously identified priority areas by the ICNF, especially those of particular interest in terms of biodiversity and those that showed the worst levels of erosion, which would correspondingly show what type of measures needed to be implemented.

4.3 Long-term recovery planning

The third phase, of long-term recovery, includes the planning and implementation of defined rehabilitation / reforestation projects to increase resilience of forest plantations, and should take place during three years after the fire occurred (Independent Technical Observatory 2018; Moreira et al. 2010). Under the resolution of the Council of Ministers No. 13/2019, Measure No. III.13 ("Payment by the State for Ecosystem/Conservation Services ") this is currently envisaged, which includes within the second paragraph the "Re-planning and Landscape Management Programme for a new rural economy in the Serra de Monchique", which can be part of this phase of the process. This program will be set out in the National Investment Programme for 2030. At the moment only 336,750 euros is available for this long-term phase (Order No. 8934-A / 2018).

This phase of recovery, the details of which are as yet unknown, should be enacted with national and regional planning instruments, namely the PROF of the Algarve, whether in terms of species to be chosen, or in defining ecological corridors and fuel management networks.

4.4 From planning to implementing recovery work.

The planning of the Monchique fire recovery operations followed the established framework and was given significant financial support. One positive feature noted was that the report on the emergency stabilisation works (ICNF 2018) was produced in good time by the ICNF. However, there are problems with implementing the recommendations within a reasonable timescale.

Thus, in early 2019 it is still not yet known when the funding for implementing the emergency stabilisation works and rehabilitation projects will be available, how many projects will be approved, and what area they will cover, let alone when they will be done or how and by whom the proposed work will be completed and monitored.

Furthermore, there are no guidelines on how certain cases will be considered, cases that are important in terms of the environment and the forestry as the area is included in Natura 2000 Network (PTCON0037 and PTCON0052), and has 74% of its area affected by fire, the Herdade da Parra National Forest, with 52% of its area affected by fire, or the areas included in the Zones of Forest Intervention (ZIF) like Perna da Negra, Odelouca, and Arade, where 76%, 53% and 71% of their respective areas were affected by fire.

Finally, from a long term recovery perspective, we know about general ideas that are of interest, but no specific information has been provided on the "Re-planning and Landscape Management Programme for a new rural economy in the Serra de Monchique", nor is the involvement of the ICNF, the municipalities, the communities and the non-governmental organisations known. Also

as yet unknown is the choice of woodland species and the form of forestry management to be promoted, nor details on how the programme will be run and who will manage and fund it.

From the above, one positive point is that there's a framework for planning and support for recovery work in its various phases. However, on the downside, we should be aware of how hard it is to move from plans to actions, especially when things are needed fast, with success dependent to a large extent on a timely response.

5. Lessons learnt

Systemic improvement, which is the central objective of the Observatory's work, is only possible with a proper analysis of strengths, weaknesses, opportunities and threats observed. In a previous report, the Observatory carried out an assessment of the system as a whole, making recommendations on the different phases and processes.

The most relevant analysis of the Monchique fire was done in 2018, and with the analysis of that year in terms of fires (which is included in the Report), the Observatory seeks to identify the most significant shortcomings of the system in use and proposes measures to address them. It is a fact that the statistics of the 2018 fires were, comparatively speaking, positive in so far as there were no fatalities, there were fewer incidents and a relatively small area was burnt(?) , but this fact is far from a guarantee of safety for the years to come. On the contrary, this is an excellent opportunity to look at the system in practice and come up with improvements.

The analysis presented here is not, therefore, a new assessment of the system, but a way of using the Monchique fire to identify matters that deserve more attention from the various players to ensure continued improvement.

We thus follow the procedures described in the previous Report (Figure 28).

Figure 28. The procedures identified in the previous Observatory Report .

In the sphere of **programming**, we continue to find deficiencies in planning to ensure work is coordinated and resources are optimised. At ground level, the clear underuse of weather forecasting data and strategic planning produced by NAD-AIR contributed to a loss of opportunity

concerning weather conditions. There should be better interaction between players in the system: technical concepts should be more standardised as should their practical application across the various bodies involved in the field of operations. The sheer diversity of organisations involved does not facilitate this process, and this should be taken into account in future restructuring of the fire fighting system. On the other hand, it is quite evident that better planning tools need to be integrated into the management system. This should be a central concern of AGIF, which should swiftly evolve into an interagency structure. If not, it has no role in improving the operational system. In this sense, the strengthening of the NAD-AIR planning cell in the ANEPC is of great strategic importance.

In terms of **fuel management**, we saw the 'perfect storm' conditions for a major fire. The fact that bushland scrub and eucalyptus dominate the landscape not only in the subregion of Serra de Monchique, but also in Silves and Meia Serra, explain the huge potential for combustibility in the area. Spatial planning should be reviewed in order to create a more diverse landscape, because a Primary Network of Combustible Materials Management is inefficient in this type of forest monoculture (particularly where eucalyptus is concerned). We also found issues with the incomplete implementation of the Primary Network compared with what was outlined in the various councils' PMDFCI programmes, in addition to its poor layout, and its low usage for firefighting. The routes for the Secondary Network seem to have had some success in protecting populated areas. We noted an absence of alternative uses for forest biomass. This could complement timber production, such as heating for small units, which would contribute to a more efficient approach to fuel management. A programme to support these alternatives would be very welcome.

One theme that has not been developed much in this report is **public awareness**. Several suggestions were left by people, with some of them already implemented in a few Algarve communities. But the fact that such a process is not yet more common, or at least perceived as such, adds weight to this subject. So we suggest that the entire area should be mapped out, with the occupied houses identified, using information obtained from residents including contact details. This information could be used by the Fire Brigade and the GNR. Thus, if residents ring 112 and give the house number, the Fire Brigade will know where to go. There were cases where people contacted 112 and were not rescued because they could not give the name of the street or road that would allow them to be found. In this sense, the Fire Brigade and GNR should arrange

visits to places they don't yet have records on, to get contact details, access information and other relevant data.

The **inspection** of mandatory fuel management duties is important, but we maintain that the previous recommendation for a review of the criteria for fuel management in the secondary networks, based on the analysis already carried out by the Independent Technical Commission, is the most technically and scientifically informed source on the subject. This recommendation also applies to the management of combustibles with regard to power lines.

There are two components in **surveillance**; fixed surveillance with the National Watchtower network, and mobile surveillance, which complements the work of the former and is used mainly in darker, less visible areas. Details of mobile surveillance are not known in this case and it is therefore difficult to assess its input. We recommend that mobile surveillance routes are always recorded and analysed. As for detection, the system in use for finding and tracking fires must be assessed by the organisation responsible for it, given the confusion that arose in correctly locating the fire. This is in line with observations of other fires, where damage from the first intervention is clear. The use of place names leads to mistakes, as in this case, so we advise the use of a precise system of coordinates that clearly identifies the approximate location of the fire.

The **initial attack** is a critical phase that was not carried out well in this fire. There were plenty of resources ready and they were swiftly dispatched. This should have led to the fire being put out quickly, despite unfavorable weather and fuel conditions. This was not, however, achieved. It is recommended that under similar weather, fuel and ground conditions, the concept of armed surveillance should be applied so that more effective work can be done with teams brought in by helicopters.

One of the most positive aspects of this incident was public safety. It has to be re-stated that there were no fatalities in this fire. Despite the difficulties of the situation in Alferce, the civil protection system and the evacuations carried out by the GNR generally worked well, so this line of action should continue to be improved, to minimise the loss of human life in rural fires.

The **extended attack** that lasted for several days in this fire merits detailed analysis, taking in a wide range of viewpoints. From the start, it is essential to establish a control strategy, to anticipate the potential of the fire to spread, and to see the windows of opportunity brought by the weather, taken together with ground and fuel conditions, as a chance to regain greater control over the situation. This approach was largely underused in this fire. Furthermore, the

firefighting strategies used and mobilisation of the forces on the ground were not as effective as they could have been. For example, with the bulldozers, despite the large number of units present, no-one took into account their operational limitations. So the use of this resource should always be considered alongside, and complemented by, other skills, such as the use of hand tools in inaccessible areas, the use of water, air support and the use of fire. In addition, for tactical fires to be efficient in fire extinguishment manoeuvres, it is essential to invest in training, and to speed up and streamline approval procedures for their use. In fires that last this long, the issue of rotation of resources is important. Rotation of resources should happen every 10 hours of work at the fire front, and must take place there, on site, so as not to lose momentum in the work.

The **post-fire and extinguishing work** was very difficult. Weather and fuel conditions were clearly problematic, but during the night and at dawn when weather conditions were better this advantage was not exploited for extinguishment work. There was a lack of strategy, a lack of commitment, an unwillingness to take orders, little motivation to use manual tools, and all of these were mentioned as reasons behind the many instances in which the fire re-activated.
There should be an external audit on situations of such severity as this fire, so as to hold to blame those who did not work when they were supposed to have done. What happened on the morning of 4th s a good illustration of this problem, as the hot spots that had been perfectly well identified should have been properly put out. The poor performance by those in charge of doing this work was a determining factor in what followed over the next few days and for the length of time that the fire went on.

The **investigation of causes** was another negative issue we found. If there are signs to suggest a specific place where the fire started and a cause associated with a power line, which EDP refutes, there is no excuse, after 9 months, for the cause to still be under investigation and reported as "unknown".

The **post-incident inquiry** is a key time for learning lessons. This would be one of the most important functions of AGIF, so that together with the other agents involved, everyone can share information and experience, working out ways of transferring information to the various organisations on the ground, and setting out communication procedures for firefighting teams as they go into and come out of the field of operations.

Post-fire recovery is essential to avoid further consequences and make the system less susceptible to fire. In this case, it would consist of the State's response in terms of: assessing needs and costs for emergency stabilisation measures; in terms of financial arrangements for

these measures; and in terms of setting up a scheme for dispensing contracts, which was prompt and generally good. However, 9 months on from the fire, the measures still need to be applied on the ground. The measures were defined, applied punctually and in a helpful and informative way, reflecting the established financial and administrative framework. However, there are administrative or bureaucratic procedures under the responsibility of State bodies that are involved in post-fire recovery that caused a significant delay in the implementation of the measures. This seriously undermined the success of stabilisation works and control of erosion, as well as the subsequent phases in the recovery of burnt areas, and these depend on maintaining the productive potential of the area. This delay also risks wasting significant funds making applications for work that is no longer needed.

Information management is important in the operations management phase and in forward planning. In this regard, operational briefings should be held in response to the present and predicted behaviour of the fire and its intensity or rate of spread. There should always be an awareness of instances in which there's a lack of necessary attention and commitment at the various levels of command. The briefings should be held with enough people to allow the Strategic Action Plan to be adjusted without compromising tactics and manoeuvre, as the success of this depends on the time taken to successfully carry out certain manoeuvres. In operations management, it is worth highlighting the role of the newly created Rural Fire Decision Support and Analysis Centre (NAD-AIR). This core group is an asset in operational management, as it issues operational analysis and suggestions for containment manoeuvres. However, for strategic planning to be effective, NAD-AIR suggestions should be taken into consideration by the Rescue Operations Commander, and this did not happen much in the first days of the fire. In any case, for this information to be complete it must be circulated in two directions. To this end, we recommend the creation of more operational teams on the ground, teams who are aware of the NAD-AIR's strategic plan, and who feed this ground information back as necessary for strategic planning. The development of the SGIF is recommended to provide necessary information for the next round of planning. It is already a very useful tool in the initial sense of a single information platform created and shared by the cornerstones of the system (ICNF, ANPC and GNR), powered by the AGIF.

The relevance of scientific research and the professionalising of personnel remains the same as our views expressed in the previous report. The Monchique fire reveals the weaknesses of a system when faced with adverse conditions. We recommend an upgrading of input – getting technicians to be better qualified, studying how to do this, and considering appropriate training. In this sense, it is very worrying to see a lack of appropriate training processes for technicians, planned, scheduled and financed, which respond to the needs identified in the existing weaknesses.

Finally, it has to be noted that no continuous learning scheme has «been put in place for assessment and incorporation of lessons learnt in order to improve the system. The role of the AGIF would be essential for this, but no visible impact has yet been seen in this regard, nor is there an assessment of the fire of Monchique and the year 2018 with the corresponding aims of improving the system. Possibly, the Integrated Rural Fire Management System and the Plan, not yet known, may clarify this matter. This analysis by the Observatory can thus contribute to this aim of improving the system. It is with this belief in the usefulness of continually learning from lessons that this Report was produced and published. That is, after all, the remit of this Observatory.

ANNEX

ANEXO 1

Lista de Abreviaturas e Acrónimos

AFOCELCA	–	Agrupamento Complementar Empresas, *Navigator e Altri*
AGIF	–	Agência para a Gestão Integrada de Fogos
ANEPC	–	Autoridade Nacional Emergência Proteção Civil
ANPC	–	Autoridade Nacional Proteção Civil
ATI	–	Ataque Inicial
ATA	–	Ataque Ampliado
BCIN	–	Brigada Combate a Incêndios
BTO	–	Briefings Técnicos Operacionais
BUI	–	Índice de Disponibilidade de Combustível
CB	–	Corpo de Bombeiros
CDOS	–	Comando Distrital de Operações de Socorro
CMA	–	Centros de Meios Aéreos
CMDFCI	–	Comissão Municipal de Defesa da Floresta
CMDFCIM	–	Comissão Municipal de Defesa da Floresta Contra Incêndios de Monchique
CNOS	–	Comando Nacional de Operações de Socorro
CNPC	–	Comissão Nacional de Proteção Civil
CNRLI	–	Centro Nacional de Reprodução do Lince Ibérico
CODIS	–	Comandante Operacional Distrital
CONAC	–	Comandante Operacional Nacional
COS	–	Comandante das Operações de Socorro
CRIF	–	Companhia de Reforço para Incêndios Florestais
DC	–	Índice de Seca
DECIR	–	Dispositivo Especial de Combate a Incêndios Rurais
DFCI	–	Defesa da Floresta Contra Incêndios
DMC	–	Humidade da Manta Morta
DON	–	Diretiva Operacional Nacional
ECIN	–	Equipa de Combate a Incêndios Florestais
EFFIS	–	*European Forest Fire Information system*
EAUF	–	Equipa de Análise e Uso do Fogo
ELAC	–	Equipa Logística de Apoio ao Combate
ERAS	–	Equipa de Reconhecimento e Avaliação da Situação
ESF	–	Equipa de Sapadores Florestais
FEB	–	Força Especial de Bombeiros
FFMC	–	Humidade do Combustível Morto Fino
FGC	–	Faixas de Gestão de Combustível
FIC	–	Faixas de Interrupção de Combustível
FRE	–	Potência Radioativa Obtida Via Satélite
FRM	–	*Fire Risk Map*
FWI	–	*Forest fire Weather Index*
GIPS	–	Grupo de Intervenção de Proteção e Socorro da GNR
GNR	–	Guarda Nacional Republicana
GRUATA	–	Grupo de Reforço para Ataque Ampliado

ICNF	–	Instituto de Conservação da Natureza e das Florestas
INFOP	–	Informação Operacional
IPMA	–	Instituto Português do Mar e da Atmosfera
IR	–	Incêndio Rural
ISI	–	Índice de Velocidade de Propagação do Fogo
MR	–	Máquina de Rastos
NAD-AIR	–	Núcleo de Apoio à Decisão e Análise de Incêndios Rurais
PCO	–	Posto de Comando Operacional
PMDFCI	–	Plano Municipal de Defesa Floresta Contra Incêndios
PNDFCI	–	Plano Nacional de Defesa da Floresta Contra Incêndios
PROF	–	Plano Regional de Ordenamento Florestal
PV	–	Posto de Vigia
RNPV	–	Rede Nacional de Postos de Vigia
SADO	–	Sistema de Apoio à Decisão Operacional
SGIFR	–	Sistema de Gestão Integrada de Fogos Rurais
SGIF	–	Sistema de Gestão de Informação de Fogos Florestais
SGO	–	Sistema de Gestão de Operações
SIOPS	–	Sistema Integrado de Operações de Proteção e Socorro
SIRESP	–	Sistema Integrado das Redes de Emergência e Segurança de Portugal
TO	–	Teatro de Operações
USG	–	United States Geological Survey
VCI	–	Veículo de Combate a Incêndios
VCOT	–	Veículo de Comando e Transmissões
ZIF	–	Zona de Intervenção Florestal

ANEXO 2

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ANEXO 3

Entidades que enviaram informação

- AFOCELCA - Agrupamento Complementar de Empresas, ACE
- ANPC - Autoridade Nacional Proteção Civil
- Câmara Municipal de Monchique
- Comando Distrital de Operações de Socorro de Faro
- Corpo de Bombeiros de Silves
- EDP - Energias de Portugal
- EDP Distribuição
- GNR - Guarda Nacional Republicana
- ICNF - Instituto de Conservação da Natureza e das Florestas
- IPMA - Instituto Português do Mar e da Atmosfera, IP