Wildfire Risk Reduction Based on Landscape Management

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Abstract Wildfires occur traditionally in the southern situated countries of Europe. However, in the last few years northern states are experiencing wildland fires (vegetation fires) which sustain their propagation for more than few hours. Reasons for

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this new situation have been discussed during the CMINE Wildfire Task Group meetings (DRIVER+ project with a mandate of one year—2019). In our paper we will summarize our main findings, which refer to two basic topics—landscape management and climate change. There are more and more parcels of land which have become abandoned because of numerous reasons, but the outcome is the same. The absent people are not cutting the trees, and the people do not bring their cattle or sheep to graze the grass and shrubs. This vegetation grows every spring and lies down on the ground every autumn as potential fire propagation fuel waiting for an ignition. Climate change is another global issue which is creating dangerous weather conditions with extreme high temperatures during the summer season plus mild winters, which is leading to wildfire occurrence in some parts of Europe year round. In our paper we will describe two case studies from Portugal and South Wales, having the same conclusions—no land management strategy and extreme weather are the best conditions for life threatening wildfires.

Keywords Wildfires · Land management · Climate change

1 Overview of the Wildfires and Their Reoccurrence Pattern in Europe

Wildfires are a serious and increasing threat throughout Europe. They occur as mega fires in the South and unprecedented fires in Northern Europe. Reason for this phenomenon is the decline of rural economies and agroforestry mosaics in Europe that create more continuous and dense forest landscapes.

The European Union in the last 20 years has invested over 103 million euro in 56 wildfire related projects. The type of projects varied from Large Scale Integrated Projects (e.g., FIRE PARADOX, FUME) to smaller projects and individual Marie Sklodowska Curie Grants (e.g., FIRESCAPE, GRADIENT). Other research projects which emphasized the demonstration of effective forest fire management, were funded under the LIFE program (e.g., ENERBIOSCRUB, MONSERRAT), or under the Civil Protection Mechanism (e.g., PREDICATE, WUIWATCH). EU funding also targeted coordination actions between research institutions (e.g., PHOENIX, FORESTERRA), and cooperative actions among neighboring countries (e.g., HOLISTIC) Fig. 1 [1].

In general, most projects have been concentrated on research in Europe, particularly around the Mediterranean Basin, including non-EU countries from this area, but research was also carried out in other parts of the world. Projects were divided into 6 thematic areas corresponding to the sequence of forest fire risk management activities. The areas most addressed by EU research on forest fire were fire prevention, fire suppression and fire science. Less attention has been dedicated to research topics related to post-fire recovery and fire detection [1].

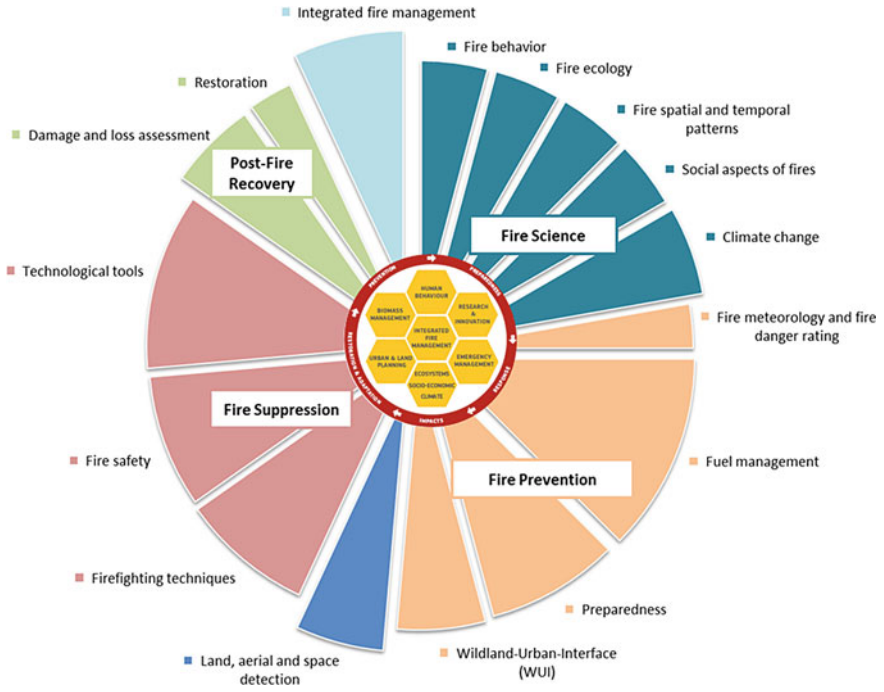

Fig. 1 The type of projects that EU has funded on the wildfire topic [1]

A more than three times increase in the period between January 1st and Dec. 9th, 2019 compared to the average number of wildfires for 2008–2018 decade has been recorded within the European Union EFFIS system as shown on Fig. 2 [2].

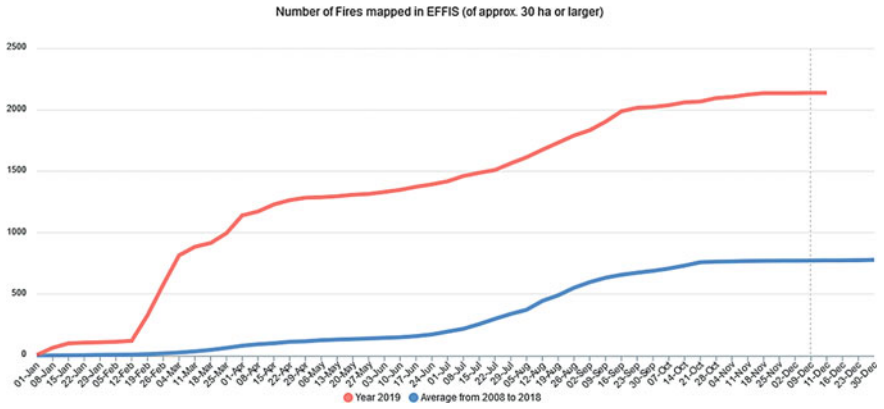

Fig. 2 Number of fires in the period Jan. 1st–Dec. 9th, 2019 (red) and average number of fires between 2008 and 2018 (blue) by EFFIS source [2]

The summer of 2018 illustrates that climate change is driving the fire regimes faster than expected. Climate change is more visible as it generates drought stress in abandoned rural areas, where dense vegetation is available for burning during wildfires. This phenomenon is not only affecting the South, but all of Europe as presented in the EU Annual Report on Forest Fires for 2018 [3]. According to the report, wildfires destroyed nearly 178 000 hectares (ha) of forests and land in 2018.

In 2017 fire season destroyed 1.2 million hectares of forests and land in Europe based on the EU Annual Report on Forest Fires for 2017 [4]. The 2017 report was about megafires as single events, the 2018 report was about globalization of such events.

The first Pan-European fire season was during the summer months of 2018. The novelty is not that fires are happening in Northern Europe, in fact, 2007, 2011 and 2014 have been notable fire seasons in these countries. What makes the difference is the fact that during the summer of 2018 Peloponnesus and Algarve burned on the same day as the forests of Sweden, Latvia, the agroforestry mosaic from Denmark and a range of ecosystems of central Europe in between. This all happened during July 23, 2018 [5].

2 Case Studies

2.1 Pedrógão Grande (Portugal June 2017) Case Study

Portuguese territory has 70% of its surface area occupied by sylvan spaces, which include forests (35%), shrubs lands and pastures (31%), unproductive land (2%), and inland waters and wetlands (2%).

The sylvan spaces that currently exist in the Portuguese territory result from the long evolutionary process always linked to the human presence. Portugal today has a forest sector with peculiar characteristics, it has one of the smallest public forest areas of the world, only 3% of the total area are public forest systems with highly productive potential and the possibility of adapting to many forest species.

The Portuguese forest has quite diverse in its composition native species (especially Quercus sp., with 36% of the total, and maritime pine, with 30%), there are also exotic species such as eucalyptus (with 26% of the total wooded surface) present.

The forest area has increased significantly between the nineteenth and late twentieth centuries, due to public policies and private actions of forestry plantations. In the public area, more than 1 million hectares were forested. However, with the increase in the number of wildfires and burnt areas since 1995 the forestry area has failed to increase and has even decreased slightly (−4.6%) in 2010.

The forest and the associated resources contribute annually to the Portugal economy with 982 million euro, not including the related value of the recreation, landscape and ecosystems services (as water, carbon retention, etc.). Traditional

forestry industries (forestry, hunting, fishing and industries) create around 80,000 jobs, mostly in regions with demographic and economic difficulties.

Despite of the high number of owners and the small size of the forest property, the goods produced this way support an important and integrated industrial chain, based on natural resources, supporting itself a strong export sector. According to an estimate for 2001 the actual annual economic output was 1.3 million euro, i.e. 344 euro per ha per year. Therefore, forest and forestry in Portugal have great importance for the economy. Portugal, in the European context and even internationally is a country specialized in the forestry sector, revenue being an important contribution to GDP. This is bigger than the European average figures. The Portugal land cover map present 35% of the country with forest (this gives first place to the state among other countries in Europe) Fig. 3.

The human activity was one fundamental element for the Portuguese landscape formation. On the most difficult landscapes, domestic animals ingested the vegetation for production of meat, milk and wool. The local population used fire to clear, heat

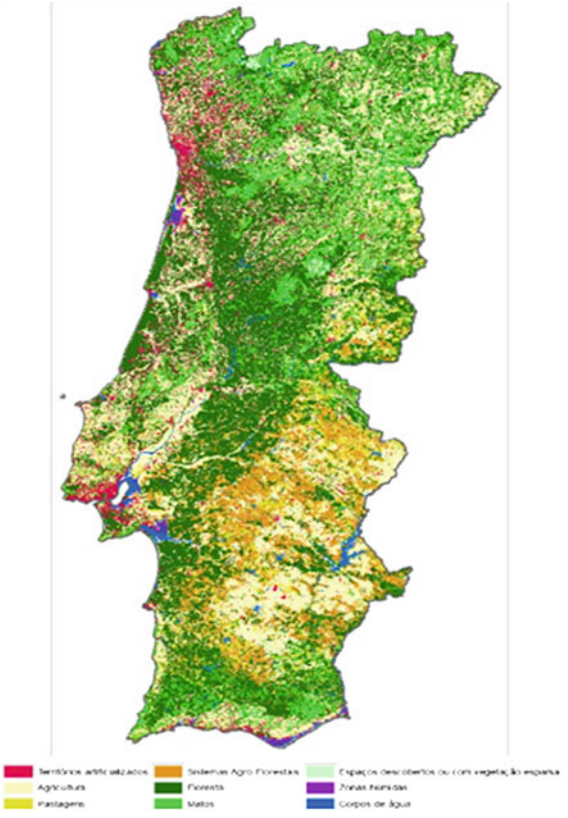

Fig. 3 Forest coverage in Portugal. *Source* Maria Caetano, Cristina Igreja, Filipe Marcelino e Hugo Costa, "Ocupação/uso do solo em Portugal Continental 1995/2010" presentation—2017 May

or cook food. Forest areas (forest and scrubland) were instruments of the agricultural success and livestock activities. They were objects of management for the goods and services they produced and, because of their value, were fostered, cared for and protected.

In the 1960s the traditional rural society foundations in Portugal began to weaken. Littoral industry, big city services and the reconstruction of Europe attracted many Portuguese people to immigrate or leave their villages and move to the larger cities. During this period the depopulation of the rural Portugal areas had begun. During that time the earlier managed plant communities which had degree of adaptation to fire, became artificially substituted by the industrial forest industry with tree species not accustomed to fire. The Portuguese farmers and Shepard's, who has historically been using fire like a tool to clean up and do firefighting were now missing. The strong agricultural community in the country, who had doing the farming, cutting the scrublands, and their animals (goats and sheep) grazing the vegetation no longer existed. "Natural fuel breaks" were no longer in place and the vegetation was growing unrestrained.

In April 1974 Portugal experienced the "democratic revolution," resulting in stronger forest control by the state. Special legislation was introduced for forested areas, preventing landowners, shepherds and farmers from using the land. With the end of the previous regime an exponential increase of forest fires started. In 1980 wildfire management was removed from the jurisdiction of the Portuguese foresters and this service was delegated to the Portuguese firefighters.

During the time period of the 1960s–1990s massive depopulation of the rural areas in Portugal was taking place. Fire as a tool to manage land and vegetation has disappeared from the population's knowledge. Fire use has been kept away and its worth as an important tool for landscape modelling forgotten. The result was the great accumulation of forest canopy, modifying the vegetation and thus becoming more prone to more intense fires, of larger size and with greater difficulties of extinction, especially during years unusually dry, associated with global warming. The end result was the large Pedrógão Grande Fire which was actively burning during 17–21 June 2017 Fig. 4.

An intense heat wave preceded the fires, with many areas of Portugal registering temperatures exceeding 40 °C (104 °F). During the night of 17–18 June, a total of 156 fires erupted across the country, particularly in mountainous areas 200 km (120 mi) north-northeast of Lisbon. The fires began in the Pedrógão Grande municipality before spreading dramatically causing a firestorm where 66 people died and more than 200 people were injured [6].

The fire was caused mainly by lack of prevention that generated accumulation of fuel which in turn generated conditions for megafire development.

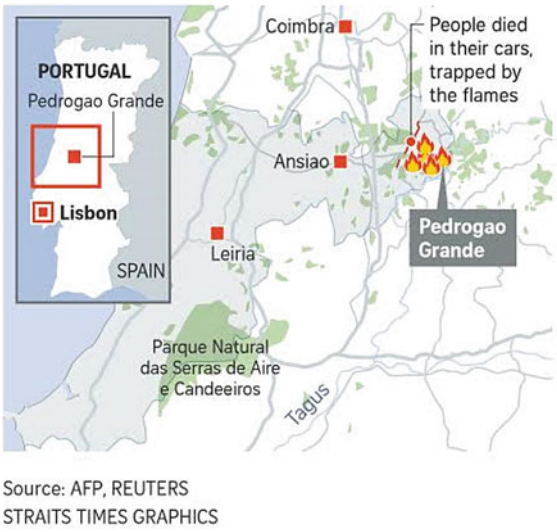

Fig. 4 Pedrógão Grande Fire location in Portugal [7]

3 Brecon Beacons National Park (South Wales April 2017) Case Study

Historically agriculture in Wales has been a major part of the economy. Wales is a largely rural country that forms part of the United Kingdom. Wales is mountainous and typically has a mild, wet climate. This results in only a small proportion of the land area being suitable for arable cropping, but grass for the grazing of livestock is present in abundance. As a proportion of the national economy, the importance of agriculture has become much reduced in recent years, and a higher proportion of the population now lives in the towns and cities in the south of the country. Tourism has become an increasingly important form of income in the countryside and on the coast. Arable cropping is limited to the flatter parts and elsewhere dairying and livestock farming predominate. Arable crops and horticulture are limited to southeastern Wales, the Welsh Marches, and the northeastern part of the country, the coastal fringes and larger river valleys. Dairying takes place on improved pasture in lowland areas and beef cattle and sheep are grazed on the uplands and more marginal land. Much of the land at higher elevations is extensive sheep-walk country and is grazed by hardy Welsh Mountain sheep. Large areas are grass and scrub lands, nearly 15% of Wales is covered by trees, the majority of this being pine plantations that were originally planned to be used as pit props for the mining industry. As with other parts of the United Kingdom, farming has been under great economic pressure, leading to declines in the number of people permanently employed on the landscape and increasing the role of part-time farming. Early farmhouses have been changed into Bed-and-Breakfast guest houses, or converted into self-catering accommodation, and farmers have diversified into the tourism-related industry and other activities.

South Wales is a loosely defined region of Wales bordered by England and the Bristol Channel to the east and south. It has a population of around 2.2 million, almost three-quarters of the whole of Wales, including 400,000 in Cardiff, 250,000 in Swansea and 150,000 in Newport. This area is the most fire prone for grass and brush fires based on South Wales Fire and Rescue Service (SWFRS) annual report 2018–19 [8].

Warm wet summers lead to an abundance of annual wildfire fuels such as bracken and Molinia grasses. Less grazing animals and changes in land use have led to an accumulation of greater dead and dormant vegetation (fuel loading). The numbers of sheep in Wales 2017 are more than 10 million, whereas in the period 2018–19 were 8.56 million head, down 473,013 head, a 5.2% decrease year-on-year. This decrease of sheep and other farmed animals has allowed an increase in the grass and brush load making the areas vulnerable in case of ignition. Wildfires can occur as soon as the herbaceous vegetation becomes dormant, usually November to May with most fires occurring in March, April and May and coinciding with Easter holidays.

Between the 8th and 9th April 2017 an area of 800 ha was burnt by a deliberate fire in the Brecon Beacons National Park, South Wales. It was once heavily grazed and a drinking water catchment for the South Wales valleys is now becoming very vulnerable to large fires. This fire spread for about 24 h in the park zone causing huge damages. Normally this type of fast progressing fires burning hectares is unusual. However official statistics from Global Wildfire Information System (GWIS) per country shows that since 2001 the United Kingdom has been experiencing wildfires of approx. 25 ha or larger see Fig. 5 [9]. South Wales has been collecting its own wildland fire statistics since 2010. The data base is maintained by the South Wales Fire and Rescue Service (SWFRS). The summary of fire investigation results indicates that most of the grass wildfires in the South Wales are deliberate. In rare cases there

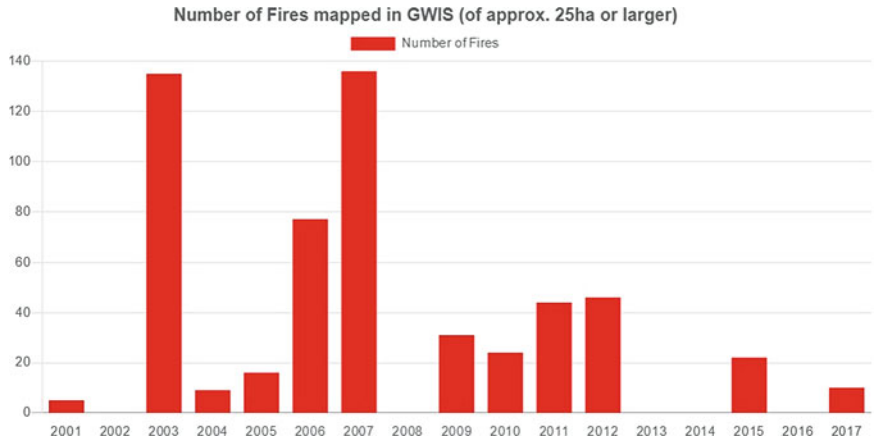

Fig. 5 GWIS statistics about UK wildfires—25 ha or larger since 2001 [9]

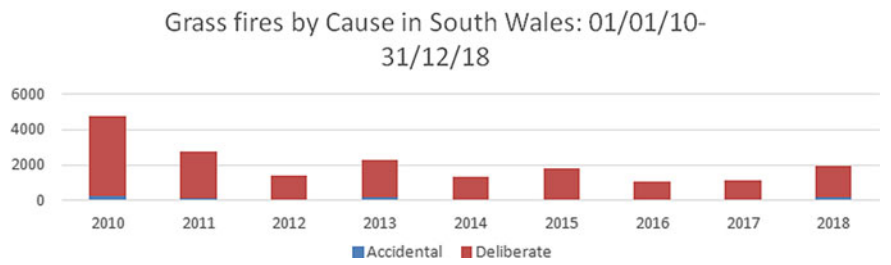

Fig. 6 Grass fires statistics 2010–2018 in South Wales source by annual report 2018–19 SWFRS [9]

are also some accidental fires, but most of these were also probably human caused. One of the reasons for such fires are that large areas of scrubland and forest are very close to residential properties.

Between 2000 and 2008 there were over 55,000 recorded grassfires and nearly 550 forest fires in South Wales, this equates to eight times more per unit area than in the United Kingdom as a whole see Fig. 6.

In order to reduce the wildfire risk in 2007 SWFRS started the "Wildfire Project". The aim of this project was to reduce the number of deliberate wildfires in South Wales. The two parts to the project covered operational tactics and equipment including community safety. Fire breaks of 800 m have been done in Wildland-Urban Interface (WUI) areas see Fig. 7.

SWFRS estimate an annual cost in their service area of around £7 m due solely to wildfires [9]. Traditionally sheep and farming animals were grazing this type of grasslands, and their reduction on the landscape is the most probable reason for such fires to easily spread. Solutions in legislative economic stimulus of the farmers to increase landscape grazing may most probably solve the problem.

4 Wildfire Paradox

In both case studies, Portugal and the United Kingdom, the main reason for fire occurrence and spread is the continuous fuel bed of dead and dormant vegetation which has been accumulated due to a lack of land management. The emergency services refer to this as the "Wildfire Paradox." The process in which the lack of forest and grassland management result in an increase in fire suppression efforts which drives further a change in fire regimes that burn at increasingly greater fire behavior. The "Paradox" is given by the fact that a rapid suppression of all wildfires contributes to creating increasingly homogeneous and greater fuel loads. The effect on the midterm is a decrease in the number of wildfires. However, given extreme weather conditions, the fires spread rapidly, becoming larger, and burning at higher intensities from the combustion of the accumulated fuel loads available on the continuous landscape.

Fig. 7 WUI in South Wales is common thus fire breaks are part of the prevention measures of the local fire brigade [9]. *Source* SWFRS

The "Wildfire Paradox" can be explained by the "Wildfire Generation" concept. Different generations are identified to explain the wildfire evolution into large wildfires burning with high intensity (i.e. megafires). In the first place wildfire became a threat due to the fuel continuity (1st generation). With time, fuel continuity increased leading to faster fires (2nd generation) and more intense fires (3rd generation). The third generation wildfires challenge fire suppression agencies as they spread fast and with a higher intensity over dense and continuous vegetation across the landscape. These fires are typically a problem from Southern countries but are now also expanding to Northern Europe [5].

Climate change impacts on temperate regions landscapes have observed this during 2018. Summers in temperate countries are traditionally wet, have all of a sudden been transformed into long, hot and dry periods. Large fuel loads have became available in a landscape without a previously defined fire regime. In these landscapes, fires do not burn as in 1st generation, but rather as 2nd and 3rd generation; fast and with high intensity. Northern countries, with large extensions of wildlands and forests have now a fire regime of increasing intensity. But fire services have not had the opportunity to approach the problem and learn or develop a need for changing tactics and strategy. They are going from fire regimes of small and rare fires directly into megafires. The only option seems to fight flames, but doing that there is a high risk of losing the big picture. In such a scenario, a defensive strategy will help fighting flames, however flames are only the visible part of a deeper problem. It is not a problem of fighting flames, it's a landscape problem.

Southern Europe is already in the 3rd generation, with two added weaknesses, the wildland-urban interface and the simultaneity of fire events. These two phenomena demand an exhaustive amount of resources and often cause the collapse of the emergency services. The more resources are deployed, the larger is the "Wildfire Paradox." Fires in the wildland-urban interface are the 4th generation and simultaneity of fire events is the 5th generation (e.g. 3rd and 4th generation fires). The immediate response is the international cooperation and support to the wildfire suppression operations. But this is not the solution, it is only temporary containment. Once the 5th generation of wildfires take place, the success of fire suppression depends mainly upon the likelihood and duration of extreme weather events. And that is uncertainty at its best. So, economy and landscape depend on uncertain weather events.

If we are keen to fight the real problem, this should be fought from the very beginning: acting on the fuel load availability and having a better understanding of fire ecology (response of vegetation and wildlife to fire) and the role of fire as a natural disturbance. Landscape management and planning should integrate wildfire risk. Fires are nothing neither strange nor exceptional. They are part of the natural lifecycle and cannot disappear. Fire seasons that before happened only in the south are now a reality across Europe. First, to reduce the fire intensity and spread rates, it is necessary to reduce the load of dead fuel. Second, to reduce fuel continuity it is necessary to restore a mosaic structure recreating a heterogeneous landscape that includes agriculture. In that sense, bioeconomy shall become a priority, as it contributes to reduce emergencies and the risks associated with climate change.

The lessons learned fighting wildfires on the past can be of great help. All are pointing at the recovery of the mosaic landscape in order to keep fire generations at the minimum. Taking a defensive strategy will only contribute to enlarge the problem, and forest will no longer be an ally but an enemy, then megafires will happen more often. The evidence of failing to see this big picture is the focus on the demanding daily emergency.

The current trend under the context of climate change is the spread of increasing fire occurrence and behavior currently happening in Southern Europe to more northern regions of Europe. Those forests that are not adapted to the new climate are experiencing renovation through disturbances. It is urgent that we face the current situation in a manner that helps forests, and societies to adapt and change, rather than take the hard strategy of preserving the current forests. We should aim to create the landscape of the future, resilient against large emergencies, protected from climate change and from megafires. Forest management and the associated bioeconomy are tools to take action.

The fire suppression services shall be well trained and provided with the appropriate resources. However, their efficiency relies upon the preparation of the landscape to fight the flames on it. Without prepared landscapes there is no possible suppression of the 6th generation fires, or 'fire storms'. They were seen in Portugal, Chile, Canada and USA in 2017, and again in 2018. The years to come will bring more.

5 Steps for Improvements

Portugal spend 25 million euro in wildfire prevention and 75 millions in wildfires combat until 2016 (average/year). The aerial support each year increase. The aeroplanes and helicopters, and the number and burned areas in Portugal also increase. However heavy equipment does not solve the wildfire occurrence problem. Thus municipalities started to experiment and implement new tactics. The municipality of Mafra, Portugal is a good example implementing prescribed fire burning into a mosaic pattern see Fig. 8.

Such initiatives on a land management scale can and will bring good results if people work together with the responsible authorities. Existing laws are static in the framework that there are now new social and climatic conditions.

The new technologies can bring added value to the land management if the fuel models represent correctly the vegetation world that can burn. Such basic system with appropriate calibration could be the Canadian fire weather index Fig. 9. This basic schema adapted to the land management daily routine can give good estimation to the land managers, how dangerous every day is.

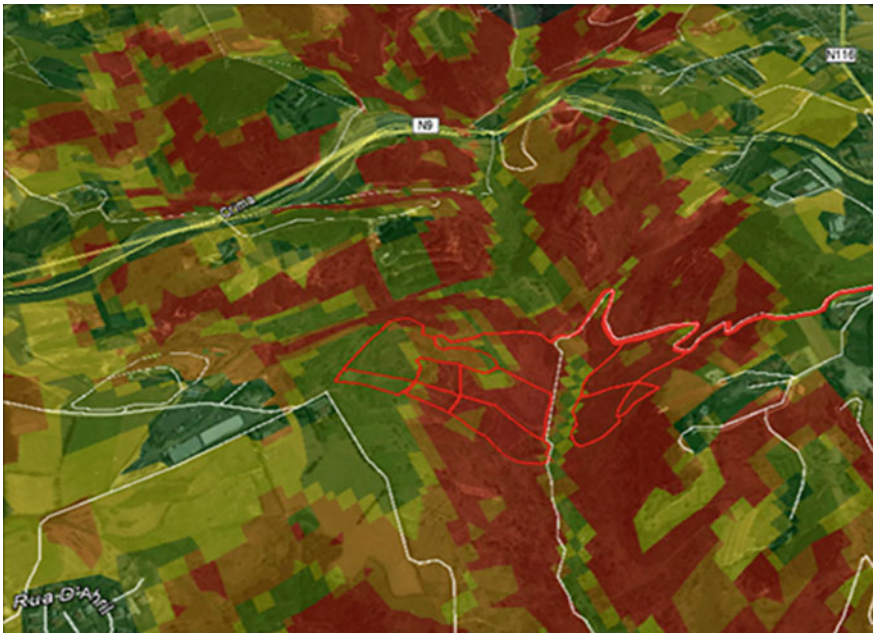

Fig. 8 Mosaic prescribed fire burned areas in Mafra municipality

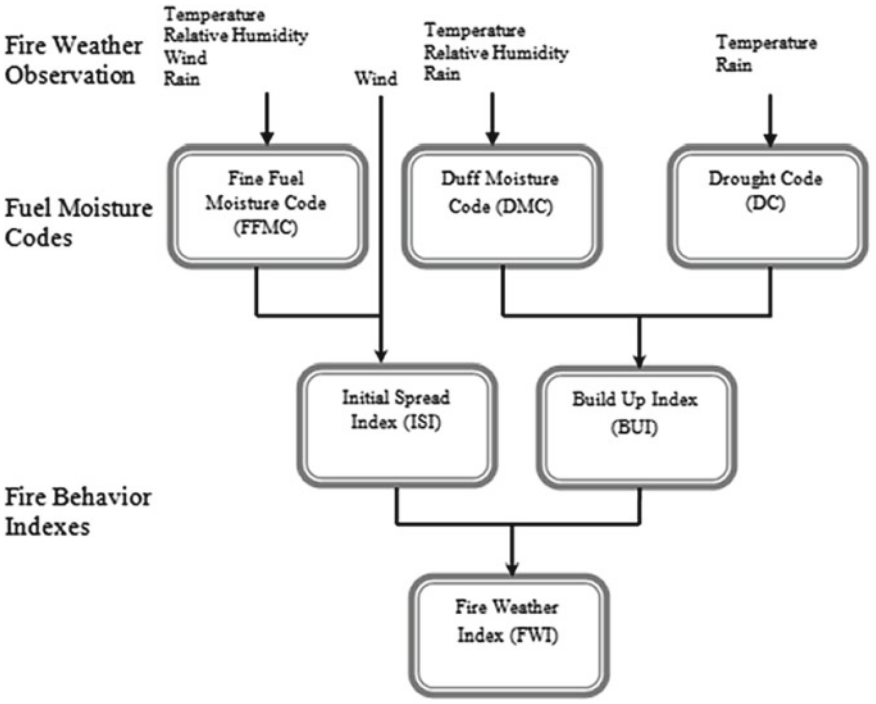

Fig. 9 Algorithm used by the Canadian fire weather index giving dynamic fire danger for the land managers. *Source* https://cwfis.cfs.nrcan.gc.ca/background/summary/fwi

6 Conclusions

The population must be proactive and do its best to maintain the land within their neighbourhoods. State reactions in most cases of rapid wildfire spread show that there is missing coordination between all first responders in the field. So, working together must cover national and all other levels up to the community representatives' special regulations and coordination cooperation initiatives which in cases of major disasters will be helpful and should be in place. The scientific community can be a pillar on simulations about potential scenarios for wildfire spread. This can help and support the civil protection decision making process. The gaps between the research community and operational response can be overcome only if all stakeholders learn to work together and the responsibilities are clear.

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References

1. Forest Fires—Sparking Firesmart policies in the EU.https://ec.europa.eu/info/sites/info/files/181116_booklet-forest-fire-hd.pdf
2. EFFIS Service for EU Countries about Seasonal Fire Trends. https://effis.jrc.ec.europa.eu/static/effis.statistics.portal/seasonal-trend/EU
3. Annual Forest Fires report of EU for 2018. https://ec.europa.eu/jrc/en/publication/forest-fires-europe-middle-east-and-north-africa-2018
4. Annual Forest Fires report of EU for 2017. https://ec.europa.eu/commission/news/annual-report-forest-fires-europe-2018-sep-20_en
5. Castellnou, M.: Why and How Forest Fires are Becoming a European Problem? https://www.efi.int/news/why-and-how-forest-fires-are-becoming-european-problem-2018-08-09
6. Rego, F.C., Oliveira, T. Fernandes, et al.: Economia da Floresta e Ordenamento do Território - Conselho Económico e Social; Lisboa (2017)
7. Reuters News Pedrógão Grande Map. https://www.straitstimes.com/world/europe/portugal-forest-fire-it-does-not-seem-real-it-is-out-of-this-world
8. South Wales Fire and Rescue Service (SWFRS) Annual Report 2018–19: https://www.fire.nsw.gov.au/gallery/files/pdf/annual_reports/annual_report_2018_19.pdf
9. Global Wildfire Information System (GWIS) Per Country. https://gwis.jrc.ec.europa.eu/static/gwis_stats/