

COST Action CA18135 “FIRElinks” Short Term Scientific Mission (STSM)

The role of fuel management smart solutions in mitigating fire risk: a review

Authors: Mario Colonico¹, Marta Serra Davos², Eduard Plana Bach²

¹ Sapienza - University of Rome, Department of “Architettura e progetto”.

² CTFC - Forest Science and Technology Centre of Catalonia. Department of Forest Policy and Risk Governance.

Abstract

Cropland and traditional forest activities abandonment are two of the main root causes for the expansion of fire risk across Europe as they generate high density young forests and consequent fuel accumulation and continuity. Moreover, climate change increases fire exposure of vulnerable landscapes.

The aim of the STSM was to collect fuel management smart solutions and best practices for fire risk management in Catalonia, Spain, and to assess if they are able to compensate for recent land use changes. At social level, smart solutions implementation could be justified by the increasing severity of wildfires. However, a cost-efficiency analysis is needed to promote them at policy level. Both wildfire risk planning and social awareness and involvement are critical issues, but they are not yet fully addressed.

Introduction

Although fires are a natural component of most of the ecosystems in the world, large or intense fires can become a major threat for both human life and the conservation of habitats and forest functions (e.g. provision of goods and services as timber, recreation or soil retention and avalanche protection). Large fires are mainly a product of extreme weather events and high fuel loads. According to Moreira *et al.* (2011), Mediterranean landscapes have increased fire hazard in the last decades, so that large fires are becoming more common because of weather changes and landscape patterns.

In Europe, and especially in the Mediterranean basin, fires are mostly human-caused (most of them due to accident causes or bad practices). Together with weather, fuel and topography related factors, they are the most significant drivers of ignition (Ganteaume *et al.*, 2013).

In Catalonia (NE Spain), the process of abandonment of traditional agro-forestry activities has been causing a strong change in landscape patterns and forest structures, especially from the last half of twentieth century (Dominguez & Plana, 2002). New young forests are growing over abandoned fertile croplands and managed forests are becoming much more vulnerable to fires because of two factors linked together. On one hand, the request for medium sized logging from forest industry, which results in shorter turnovers and

medium-size trees (not taller than 15-20 m when potentially some commercial pine tree species could reach more than 35-40 m in height). These human-managed forest structures, because of the abandonment of traditional extensive grazing with cattle controlling the understory vegetation and/or the proper thinnings, become dense forest stands with a vertical fuel continuity and high vulnerability to crownfires (Fernandez-Alonso et al., 2013). In a context of climate change, extreme weather conditions such as droughts and heatwaves could become more frequent, making forests more exposed to wildfires exceeding suppression capacity (Plana et al., 2018).

Many experiences have been carried out in order to raise awareness for the need for resilient and resistant landscapes to fire (Plana et al., 2015; Rego et al., 2018; United Nations Office for Disaster Risk Reduction, 2018). However, even if from a scientific and an empirical point of view solutions have been found time ago, it seems that the process of understanding and decision making at policy and social level proceeds slowly. For these reasons, communication and awareness campaigns are complementary tools to demonstrate at social level that possible solutions to make exposed landscapes less vulnerable exist. Such an effort is continuously done by institutions such as CTFC (Plana et al., 2016). At policy level, cost-efficiency analysis and legal issues are important, too (Plana et al., 2010). The necessary defensive strategies and reinforcement of fire response and suppression do have an effect on contrasting small sized fires, but not the large ones (Xanthopoulos, 2007). However, the necessary efforts in response without the complementary actions in prevention are, paradoxically, concurring to fuel accumulation at landscape level (Biro & Rigolot, 2009; Fernandes, 2008). For this reason, along the fire risk cycle, it is crucial to reinforce prevention actions to be able to reduce the global exposure and vulnerability of the system. In fact, investing more in prevention and preparedness results in less efforts on response, as it is shown, for instance, in the ongoing project "Prevail - Prevention action increases large fire response preparedness" (www.prevailforestfires.eu). Fuel management can make large fire suppression more effective and less costly. Smart solutions are cost-effective measures that can help reach this goal under limited budget, as it is shown, for instance, by Plana et al. (2010).

However, in order to make fuel management tools effective, it is necessary to cope with recent and rapid societal and environmental changes such as the process of land abandonment or, on the opposite, the colonization of wildlands in some areas. Therefore, it is necessary to integrate wildfire risk planning into spatial and urban planning and to move towards a reconceptualization of the relationship between wildfire and society, which implies a higher degree of social and political commitment (Plana et al., 2015; Plana et al., 2016).

Materials and methods

A selection of smart solutions and best practices directly or indirectly involved in fuel management and fire risk reduction that have been adopted in Catalonia (NE Spain) were done and analysed. Smart solutions are "practical measures and initiatives implemented in a sustainable manner, enhancing the cost-efficiency ratio, optimising the synergies and cooperation from a multi-objective perspective, able to capitalize the best existing knowledge and being permanently updated under a 'lessons learned' approach" (cf. Prevail project, www.prevailforestfires.eu).

The regional level was chosen since Catalonia has the competences on forest management and fire prevention transferred and it is one of the Mediterranean regions where the institutional frame of wildfire risk management is more developed.

Smart solutions were identified by interviewing a selected number of agencies and enterprises working on current fuel management programs. The selected institutions are summarized in Table 1. Questionnaires were administered to the above-mentioned institutions in order to assess if any smart solution was or had been led by them over time or if they knew about any other.

Rather than the impact of smart solutions on fire risk management, their feasibility was assessed from the technical, economic, social, environmental and legal points of view.

Results and discussion

The institutional frame in Catalonia has been wide developed, partially as a reactive consequence of the several wildfire events suffered, especially from the 1980s. Our results show that all the stages of the risk management cycle are nowadays covered (Table 1). However, most of the efforts (in terms of resources allocated) are done in the response phase, and the less in the preparedness one (enhancing the exposed population capabilities). Although no inter-agency connecting the different competences exist, several protocols or collaborations have been established, especially among the Forest and Fire Service during the fire risk assessment and planning. A clear gap still exists towards a better integration of risk management in the rural and urban planning, in terms of mosaic landscape contribution and development of building codes and prescriptions as tools for exposure and vulnerability reduction. Nevertheless, during last years, different initiatives have been started addressing this issue, and the existing map of institutions, the legal frame, and the increasing politic awareness about the complexity of wildfires issue are favouring a shift towards integrated risk management approaches. For instance, in most of bottom-up approaches from the territories or at municipality level, the participation of all actors in the risk planning and management is more and more common.

TABLE 1. List of selected Catalan institutions involved in wildfire risk management cycle and fuel management (in green). Main competences and collaborations within the risk management cycle (in blue).

ID	Institution	Main competences within the Risk Management Cycle			
		Prevention	Preparedness	Response	Recovery
1	General Directorate of Forest Ecosystems and Environment Management_Ministry of Agriculture Cattle Fishing and Food (MoA)	Fire risk assessment and planning. Fuel management (including prescribed burning)		Participation in the emergency room	Direct investment and support to restoration of burnt areas
2	The Forest Ownership Centre (CPF)_MoA	Forest planning in private forests. Fuel management			Support to restoration of burnt areas
3	General Directorate of Rural Rangers_MoA	General control of activities in rural areas. Small unit for fuel management and social awareness (GEPiF)	Territory monitoring and access control in high fire risk periods	Participation in the emergency room. Small unit of suppression support (GEPiF)	Fire impact assessment. Support to restoration (GEPiF)
4	General Directorate of Rural Development_MoA	Support to mosaic landscape			Support to restoration of burnt areas
5	General Directorate of Agriculture and Livestock_MoA	Support to mosaic landscape and extensive livestock farming			Support to restoration of burnt areas
6	General Directorate of Civil Protection_Ministry of Home Affairs (MoHA)		Public awareness	Coordination of the emergency room	
7	General Directorate of Fire Prevention, Extinction and Rescue_MoHA	Collaboration with GD of Forest in planning prevention actions. Prescribed burning for training		Suppression	
8	Office of Urban and Territory Agenda_Ministry of Territory and Sustainability	Integration of risk assessment of natural hazards into urban planning			
9	Province Authorities ¹	Own programs of fuel management (e.g., fire breaks around urbanizations) and fire prevention planning	Community awareness		Support to restoration actions of burnt areas
10	Forest Defense Associations ²	Implementation of prevention measures	Territory monitoring in high fire risk periods	Collaboration with the Fire Service	Collaboration in restoration actions

1: The extension of fire prevention programs depends on each one's priorities and budget availability. Province of Barcelona has the most complete program, followed by the Province of Girona.

2: They are private associations. Nevertheless, they are fully integrated into the national system of fire prevention and suppression and they are supported by public funds (equipment, training, coordination for the emergency management, etc.).

So far, 10 different initiatives have been collected that can be considered as smart solutions (Table 2). A detailed description of the smart solutions can be found in the PREVAIL project website.

TABLE 2. List of the selected initiatives that can be considered as smart solutions as they are initiatives that seeks to reduce fire risk, being at the same time "implemented in a sustainable manner, enhancing the cost-efficiency ratio, optimising the synergies and cooperation from a multi-objective perspective, able to capitalize the best existing knowledge and being permanently updated under a 'lessons learned' approach".

ID	Initiative	Short description	Components				
			Forest management	Grazing	Mosaic	Prescribed burning	SMP
1	LIFE Demorgest	It is a LIFE+ project which aims to reduce the vulnerability of forests in Catalonia to large forest fires by facilitating the adoption of new models of multifunctional forest management that include the production of various goods and services to promote large fires prevention. Also, it raises awareness among the general public about the role of forest management in fire risk management and the conservation of agricultural landscapes.	X			X	X
2	Fire flocks (<i>Ramats de foc</i>) project	The project built up a production and consumption chain of food products from herds with the added value of decreasing fire risk in woodlands with a recognized strategic role in the propagation of wildfires. It strengthens the links between wildfire management services, farmers and local butchers and restaurants. A commercial label that certifies the herds' fire risk management tasks was promoted.		X			X
3	LIFE Montserrat	It is a Life+ project which seeks to i) develop ecosystem-based measures to increase resilience and stability of forests against fires, ii) contribute to biodiversity conservation and improvement in Montserrat area which is included in the Natura 2000 network and iii) preserve biodiversity by increasing the ecosystem connectivity through the creation of a mosaic of scrub, natural grasslands and forests The project states that targeted grazing could be expected to successfully reduce fuel loads.	X	X		X	X
4	Assessment of biomass availability in the town of Calonge	The objective of the initiative is to assess the biomass availability to supply the heating network of local public equipments. The objective of the initiative is the assessment of forest areas based on the accessibility, the growth of forest biomass and the reduction of fire risk, in order to make a rational and sustainable use that does not endanger the resource and perpetuate them over time.	X				
5	GEPRIF Project	Main objectives of the project are i) to evaluate in an integrated manner preventive treatments of forest fuels to reduce the severity of fires, ii) to predict the potential severity of wildfires and the effects of preventive treatments and to define priority areas of action and iii) to evaluate the economic efficiency of prevention, extinction and restoration activities.	X			X	

6	Promobiomasse Project	It is a European Interreg Sudoe project that aims to promote forest biomass energy market in Southwestern Europe. The main objective is to develop, test and validate an integrated “short circuit” biomass market management model that can be extended to most of the forested areas in Southwestern Europe. The promotion of biomass is directly related to the “exploitation” of forests and, thus, to the reduction of wildfire risk.	X				
7	LIFE Pinassa	It is a European Life+ project whose main objective is to preserve black pine forests, stated the progressive regression of its habitat. Main objectives of the specific action “Strategic silvicultural actions for the prevention of great forest fires in Pinus nigra forests” are i) to reduce the risk of great fires through a strategic management points approach and ii) to obtain black pine forest structures that guarantee ideal fire behavior for extinction as well as control, and which avoid the generation of high intensity fires.	X			X	
8	Vallès Forests project	This project is based on the structuring of a biomass buying-selling market to achieve a good forest management able to both protect from wildfires and revitalize the forest sector by creating a local cycle of biomass production and combustion for energy needs. This is an innovative project in Catalonia because it enhances wildfire prevention through biomass valorization. The energy created through this biomass serves to provide energy to different public equipments.	X				
9	Sustainable Forest Management Orientations for Catalonia (ORGEST)	It consists of specific guidelines for the management of different forest types in Catalonia. For each forest structure and type, specific objectives are targeted with regard to the socio-economic and environmental contexts. Among the others, the guidelines integrate a specific indicator of sustainable forest management, the “large-fire risk” indicator, which has to be mitigated through i) the production of wildfire types risk maps and ii) the elaboration of forest management models that include fuel management.	X				
10	Perimeter of Priority Protection (PPP) ET2 “Tivissa-Vandellòs-Llaberia-Pradell”	34 PPPs are defined in Catalonia following physical limits of large forest massifs. Several fuel management actions for fire prevention in strategic areas within the Montsant massif PPP were planned, including vineyards cultivation which are proved to act as firebreaks.	X		X		X

The selected smart solutions that were collected were then summarized in 5 groups representing the “types of initiatives”: prescribed burning, recovery of grazing, Strategic Management Points approach (SMP), forest management and restoration of a mosaic landscape in rural contexts. Their feasibility in terms of technical, economic, social, environmental and legal points of view was assessed.

The usability of the well-known prescribed burning as a smart solution was assessed with regard to social and legal/policy constraints in particular. In fact, it is absolutely cost-efficient from an economic point of view (Duane et al., 2019). Also, in fire-shaped environments with fire-adapted species and communities, it is not a danger for nature conservation (Artman et al., 2001). If well planned, it is feasible also from a technical point of view (Ascoli et al., 2009). Problems and limitations have been reported typically in terms

of social acceptance and policy support because of the low knowledge about the “good fire” contribution for fire prevention, together with practical issues as the smoke produced and other legal constraints related with artificial burning (Fernandes et al, 2013, Schults, C, 2018).

Grazing is a second smart solution that needs to be financially supported with proper policies. It has been carried out along the history, in fact the phenomenon of land abandonment is recent (Lasanta et al., 2017). It is feasible from the technical point of view as it is a well-known traditional activity of rural Catalonia. Also, it would be accepted from society as the restoration of a disappearing traditional land management technique. However, it needs to be strongly financed at policy level since pastoralism is a low profitability, time consuming and experience-based job. Very interesting initiatives are “Rurbans - School of shepherds” in Catalonia (<https://www.accesstoland.eu>), an association to rejuvenate mountainous areas and foster a new generation of shepherds, and “Fire flocks” initiative (<https://www.ramatsdefoc.org>), a project with the aim of supporting the contribution of herds to fire risk management through grazing in forest areas with the promotion of a commercial label for direct consumption in cooperation with restaurants and the tourism sector.

Also, a smart strategy implemented in Catalonia is the so called “Strategic Management Points” (SMP) approach (Costa et al., 2011): starting from the identification of critical points (i.e. areas where changes in fire behavior are likely to be significant and lead to opportunities for fire-fighters to stop a fire), infrastructure features within a critical point are planned, realized and maintained to facilitate the extinction of fires. It is technically complex to plan such a strategy, also because it must consider that many stakeholders are involved in the implementation and maintenance of SMPs. Considering the limited budget, this selective approach of fuel management sites has been well assumed at policy level. However, this initiative still keeps a certain level of risk, since the vulnerability of the landscape at forest stand level into the polygons defined with the net of points is not reduced.

Forest management for roundwood, wood chips for biomass and traditional firewood production could also be a smart solution for fire prevention from a cost-efficient perspective, especially when they are complemented with extensive breeding of the understory (Plana, 2010). In particular, an active forest management aimed at promoting high forests with high stumpages will also offer a more resilient structure as tall trees create a vertical discontinuity with the understory, thus preventing crown fires. In some cases, the guides for forest management from the “The Forest Ownership Centre” are integrating fire prevention as a main objective (Piqué et al., 2011). For these reasons, the EU funded project “Life+ Pinassa” was selected as a smart solution. The project aims to promote, among other objectives, the increase of the resistance and resilience (capacity of self-defence and recovery) of Catalan black pine forests to both large fires and climate change (<http://lifepinassa.eu>) through forest management and the improvement of the biodiversity of young, dense and simply structured black pine forests, the regeneration of heavily exploited ones or of those intensively affected by large fires.

Finally, the restoration of the mosaic landscape through the promotion of vineyards and truffle plantations in abandoned lands, where typically cereal or other old crops are not implemented anymore, is to be considered a smart solution. For instance, several SMPs are being implemented enlarging croplands, e.g., in PPP-ET2, where permission for new vineyards has been managed to create new croplands as a fire prevention infrastructure. This is really changing the landscape in some sites, since without this “added value” of the products, no use of that lands would be made.

However, in case of extreme weather conditions and high volumes and continuity of fuels, mosaic landscapes, SMPs and fire-fighting efforts could not be enough to stop wildfires from becoming large and severe. For this reason a more integrative preventive strategy is a key factor to cope with future challenges posed by wildfires in a context of climate change. Hitherto, one of the selected smart solutions was the Life Montserrat project (lifemontserrat.eu), where a multi-objective result was obtained: ecosystem-based measures to increase the resilience and stability of forests against wildfires were developed, together with actions for the conservation and improvement of biodiversity and landscape quality to connect two Natura 2000 sites. The main goal of the project is to implement a strategic management points approach maintained with traditional activities as grazing and also to integrate the prescribed fire as a tool for fuel reduction. LIFE Montserrat is also promoting forest clearings and zootechnics beyond the strategic points.

Conclusions and contribution to the COST Action CA18135 aims

A set of initiatives representing possible smart solutions towards more integrative and cost-efficient wildfire risk management were collected in Catalonia, Spain. We highlight that, before being implemented, it is necessary that smart solutions exist and are feasible and applicable. Thus, they have the potential to be a more powerful and cost-efficient tool than focusing all the efforts in suppression.

Integrating the forest and agricultural activities into the fire risk management allows a more cost-efficient use of the typical limited budget for prevention actions.

In most cases, technical solutions already exist. The smart approach is their implementation in synergy with several objectives. For instance, fire prevention can improve the local economy, promote the biodiversity conservation or enhance the social understanding on the role of fire in the ecosystems. Moreover, the selected smart solutions are based on a collaborative partnership among private and public actors, with a bottom-up approach in coherence with a common strategy at regional level in which research institutions such as CTFC are aligned. Also, smart solutions connect the beneficiaries of fire prevention with the Forest and Fire Service, strengthening the shared responsibility approach of the risk management.

However, social and political support is crucial for the future implementation of smart solutions. Social awareness can be reached by means of accurate educational and informative campaigns about fire as a component of the Mediterranean ecosystems and the challenges of the wildfire risk management related to climate and socio-economic changes. Policy attention can be more easily reached by cost-efficiency analysis showing the benefits of preventive actions complementarily to suppression efforts, from the perspective of avoided costs of potential fires.

Smart solutions transferability among different EU contexts and among forest owners, farmers, fire operators and citizens can be allowed and promoted by assessing how structural factors such as forest ownership, legal issues and socio-economic constraints could be overcome.

The STSM offered the opportunity to collaborate with a center of excellence as CTFC. It is a R+D Catalan institution formally linked to the regional Ministry of Agriculture. The STSM let the applicant know the research projects and transference outcomes achieved by the institution regarding the smart solutions above mentioned.

The selected sample of initiatives and others that will be collected in both Spain and Italy will be the basis for a further analysis whose objective is to find a way to overcome structural factors to let smart solutions be shared among different fire risk exposed European contexts, hopefully in the frame of "Prevail" project.

The present STSM will contribute to the COST Action CA18135 by increasing knowledge about initiatives for the effective fire risk management of fire-prone landscapes. It will contribute to spread the awareness that best practices exist and are cost-efficient alternatives with respect to a prominent fire-response approach.

The analysis of the institutional framework together with the cost-efficiency analysis is needed to provide decision makers a tool for the implementation of integrated decision support systems for future policies, including the strengthening of Rural Development Program measures that directly or indirectly affect forest and rural fire risk.

For the above-mentioned reasons, the present STSM contributes to the STSM Working Group 5 "Socio-economic aspects of fire and fire risk management" aims and scopes.

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