Funded by

European Union Humanitarian Aid

and Civil Protection

PREVENTION ACTION INCREASES

LARGE FIRE RESPONSE PREPAREDNESS

Grant Agreement No. 826400-PREVAIL-UCPM-2018-PP-AG

Deliverable 5.1 – Decision support system for effective fuel management: application to Cascais Case Study (Portugal)

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15 March 2021

Project name: Prevention Action Increases Large Fire Response Preparedness (PREVAIL)

Financed by: DG ECHO 2018 Call for projects on prevention and preparedness in civil protection and marine pollution

Website: http://prevailforestfires.eu/

Partnership: Università degli Studi della Tuscia - UNITUS (Coord.), Università degli Studi di Napoli Federico II – UNINA, Centre de Ciència i Tecnologia Forestal de Catalunya - CTFC, Ellinikos Georgikos Organismos - DIMITRA, Instituto Superior de Agronomia – ISA

Duration: 2019 – 2021

Data of deliverable: Deliverable 5 – Decision support for effective fuel management Task 5.1. Identification of the existent free tools that help to prioritize fuel hazard reduction areas (critical points), and Task 5.2. Involving end-users enhancing local economy.

Date of deliverable: 15/03/2021

Lead partner of task: Instituto Superior de Agronomia – ISA

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1. PREAMBLE

The management of forest fuel is an important element of forest fire prevention because forest fuel is the element of the fire triangle that can be modified by human action and mitigate the potential occurrence of unwanted and severe wildfires (see Figure 1). Forest fuel is composed of all kinds of plant material, including grasses, shrubs, trees, and dead leaves. Large fuel loads will result in larger and faster wildfires, and hence, more difficult to manage.

Figure 1. Fire triangle. Retrieved from Wikipedia (https://pt.wikipedia.org/wiki/Ficheiro:Fire_triangle.svg).

Fuel management, although it is seemingly a simple issue (i.e., remove vegetation), is actually a very complex matter, which includes identification of the need, objectives to be achieved, priorities to be identified, limitations to be observed, and real-world application. The Fuel Management Decision Support System proposed here is intended to be a road map to help forest fire managers in these tasks. It aims to provide a clear and easy-to-apply methodology for planning fuel management activities in a particular area of interest.

2. STATE OF THE ART

2.1. WILDFIRE DECISION SUPPORT SYSTEMS: GENERAL CHARACTERIZATION

Wildfire Decision Support Systems (DSSs) are integrated information systems that collect, manage, and analyze input data using different interfaces, to help supporting wildfire management decision making. A description of most of the existing wildfire DSSs can be found in detail in Xanthopoulos et al. (2002), Minas et al. (2012), Mavsar et al. (2013), Martell (2015), Pacheco et al. (2015) and Sakellariou et al. (2017).

Overall, as input data, a wildfire DSSs needs up-to-date geospatial and satellite data on meteorology, land cover, fuel moisture and fire history. These data are necessary for deriving predictions of fire behavior and propagation through simulation models. It is important to keep in mind that the results of a DSS will be substantially influenced by the quality of the input data.

Simulation models of fire behavior constitute an important module of Wildfire DSSs and aim to assess fire risk and carry out planning of preventive fuel treatments. Fire behavior modeling took the first steps in 1920s in the USA by relating wildfire spread and environmental variables. Since then, several fire spread models were described in the literature. For example, there are physical models (based on the physical characteristics of the combustion) and empirical models (based on information collected in real fires). There are also operational models that bring together part of the accuracy of the physical models and part of the user-friendliness of the empirical models. Other examples include probabilistic models that are based on contingency tables rather than on physical and statistical equations, and semi-empirical models, which are based on the physical principles of fire behavior but also integrate experimental information (Sullivan, 2009).

Rothermel's model (1972), modified by Albini (1976), is a semi-empirical model and is still today one of the most used fire spread models in different fire simulators such as Behave Plus (Andrews, 2014), Farsite (Finney, 1998), Flammap (Finney, 2006), Landscape Treatment Designer (Ager et al., 2012), and Wildfire Analyst (Technosylva).

From the above-mentioned fire simulators, Behave Plus, Farsite and Flammap are the most widely used (PLURIFOR, 2019) (Table 1).

Table 1. Required input data and outputs of the three most used fire simulators.

Simulator name and basic characteristics	**Input data required**	**Output**
Farsite Computes wildfire growth and behavior for long time periods under heterogeneous conditions of terrain, fuels, and weather	- Spatial information on topography (elevation, slope, and exposure) - Spatial information on fuels (canopy cover, canopy height, canopy base height, canopy bulk density, fuel moisture, fuel models) - Weather (precipitation, temperatures, and relative humidity) and wind files (wind speed and direction) - Ignition point/line/polygon Download at https://www.firelab.org/project/farsite	- Raster or vectorial maps of fire spread and fire behavior (speed of spread, flame length, intensity)
Flammap Describes potential fire behavior for constant environmental conditions (weather and fuel moisture)	- Same spatial data on topography and fuels as Farsite Download at https://www.firelab.org/project/flammap	- Raster or vectorial maps of fire behavior, fire probability, fire paths (main spread vectors), and Minimum Travel Time - Map of optimization of preventive treatments (locations of interest to prioritize fuel treatments)
Behave Plus Models fire behavior and some fire effects	- Interactive user input (fuel moisture, weather, etc.) - There are no default values for input parameters Download at https://www.frames.gov/behaveplus/home	- Graphs, tables, and simple diagrams that aid interpretation of results

Finally, a wildfire DSS may also include the operational output, i.e., integrate or relate to interfaces that will help managing the preparation, planning, coordination, and dispatch of forces of fire departments (Sakellariou et al., 2017).

The common outputs of Wildfire DSSs are a set of maps, figures, tables, and supporting text that (Noble & Paveglio, 2020, p. 3):

1) defines the geographic target area for the decision-making,
2) assesses the existing elements at risk,
3) recommends the appropriate chief of operations organization level,
4) lists relevant strategic management objectives,
5) selects a course of action to achieve objectives,
6) provides overarching rationale for course of action,
7) enumerates an estimated final cost,
8) lists the individuals authorized to approve the decision.

2.2. TYPES OF WILDFIRE DECISION SUPPORT SYSTEMS

Wildfire DSSs can be grouped according to the resources they use (input data and interfaces) and their objectives (Sakellariou et al., 2017). In this sense, three major types of wildfire DSSs can be identified:

1) use database management systems and mathematical/economic models whose aim is mainly to optimize actions of firefighting forces in space,
2) use forest fire simulators and satellite technology that are more directed to the rapid detection and prediction of forest fire spread,
3) use geographical information systems platforms and are more focused in developing strategic and operational plans.

According Pacheco et al. (2015), the four most currently used wildfire DSSs are (i) the Canadian ‘‘Level of Protection Analysis System – LEOPARDS” (McAlpine & Hirsch, 1999), (ii) the Chilean “KITRAL System” (Pedernera et al., 1999), (iii) the North-American “Wildland Fire Decision Support System – WFDSS” (Noonan-Wright et al., 2011), and (iv) the Spanish ‘‘Sistema Nacional para el Manejo de Incendios Forestales/Fire Economics Evaluation System – SINAMI” (Rodríguez y Silva et al., 2010). All of them integrate GIS, fire simulators, and economic models of costs and losses (Table 2).

Table 2. Main characteristics of the four wildfire DSSs most used. Retrieved from Minas et al. (2012) and Pacheco et al. (2015).

Wildfire DSS	Description and website
LEOPARDS	- Decision analysis tool that can be used to predict the costs and impacts resulting from a set of fire management policies and budgets. - The primary component is a deterministic, spatially conscious simulation model that emulates the daily fire suppression activities of a provincial fire management agency. LEOPARDS webpage not found. Hirsch & Fuglem (2006) referred LEOPARDS high complexity, which may constrain its use over the following period.

KITRAL	- System designed for the permanent assessment of forest fire occurrence. It facilitates the decision making in prevention and suppression activities against fire. - Composed by several independent and interconnected modules, such as Fire Weather Module, Fire Risk Index, Fire Simulator, Daily Operations Programming System, Dispatch System, Statistical Processor and Strategic Planner. Project website available at http://linfor.forestaluchile.cl/simulacion-de-incendios-forestales/ (KITRAL webpage not found)
WFDSS	- Interactive web-based system that includes fire modeling subsystems and economic tools to facilitate and optimize the decision-making process during forest fires events - The first fundamental element of this DSS is the fire simulation system Available at https://wfdss.usgs.gov/wfdss/WFDSS_Home.shtml
SINAMI	- First attempt by the Spanish National Forest System to help agencies with fire responsibilities perform an economic analysis of their budget requests for fire management and protection (Rodríguez y Silva et al., 2010) Project website available at http://franciscorodriguezysilva.com/laboratorio/proyecto-sinami/ (SINAMI webpage not found)

In the present, the DSSs referred in the table above whose webpages were not found are not being used generally, not only because of its complexity, but also because they were the outputs of scientific projects and were not implemented afterwards by the competent authorities (as shown in references such as Hirsch & Fuglem (2006), and the news section of KITRAL's developer webpage (University of Chile, https://www.uchile.cl/undin2/actuales/noti2811.shtml, 2003)). Although these DSSs may be used by technicians from time to time, there is no available information for their generalized use.

2.3. Fuel Management Decision Support Systems

Fuel Management DSSs are not as developed as Wildfire DSSs, since they are usually incorporated as a module of the Wildfire DSSs.

The most developed and sound Fuel Management DSSs is the North-American "Interagency Fuels Treatment Decision Support System – IFTDSS" (Drury et al., 2016). IFTDSS was first released in 2017 and is a web-based application designed to make the planning and analysis of fuels treatment more efficient and effective within the context of the USA (Wheeler et al., 2010), project website: https://iftdss.firenet.gov/landing_page/about.html. This DSS follows a landscape planning cycle, split in five tasks (landscape evaluation, strategic planning, implementation planning, monitoring, and reporting) (Figure 2). It uses the software Map studio as the mapping interface, which is a separate module where the models are run. IFTDSS is still being improved as it is comprehensive and requires large data inputs, which sometimes can be challenging for fire managers (Noble & Paveglio, 2020).

Figure 2. Landscape planning cycle and detail of the landscape evaluation tasks of IFTDSS. Project website: https://iftdss.firenet.gov/landing_page/about.html.

However, to our knowledge, there is no comprehensive Fuel Management DSS developed for Europe. The only project on a Fuel Management DSS that was to be developed for Mediterranean Europe was *Fire star*. It aimed to assist end-users in the assessment of wildland fire risk for people and infra-structures, and in the assessment of the preventive efficiency of wildland fuel reduction (European Commission, 2005). However, this DSS never came to actual results.

2.4. Limitations and barriers for the use of a Decision Support System

In view of the increasing complexity of the DSS structures and the amount of data required (regardless of the field), Koukoutsis et al. (2020) listed the main limitations and barriers of a large DSS, which are worth to keep in mind, in order to create a viable DSS. Main limitations and barriers are: "(1) The efficient updating of the DSS; (2) The flexible expansion of the DSS; (3) The consistent reduction of the information system; (4) The ability to modify the system; (5) The upgradability of the DSS".

Indeed, some of the barriers to wildfire DSS use are not only social and institutional, but also technical, such as lack of updated evaluation of fire risk under recent changes on fire regime (which may lead to extreme fires) and lack of confidence on fire spread models used (Rapp et al., 2020).

Furthermore, Koukoutsis et al. (2020) also listed the characteristics that the meta-database of the DSS needs to have in order to tackle the above-mentioned limitations, which include:
"(1) A complete thematic decomposition; (2) A complete list of all indicators and/or data and their acquisition or evaluation method(s); (3) A complete list of all the external sources of the system, together with the way to access them; (4) An absolutely sufficient and structured description of the experts' knowledge concerning the whole system; (5) The proper documentation and navigation information for users in this (teleological) meta-database".

From the above-mentioned needs, we highlight the importance of expert knowledge concerning the whole system. A comprehensive DSS needs to be a deliberative process that includes all relevant stakeholders involved in decision-making related to forest and fire management (Rapp et al., 2020). Such a DSS should allow stakeholders to weight the importance of objectives or elements at risk, assess the relative costs and benefits of tactics across these objectives, and discuss conflicts, trade-offs and synergies that may result from different decisions (Rapp et al., 2020).

3. PREVAIL DECISION SUPPORT SYSTEM FOR FUEL MANAGEMENT – PREVAIL DSS-FM

3.1. INTRODUCTION

PREVAIL decision support system for fuel management (PREVAIL DSS-FM) is proposed to address the research gap found on Fuel Management DSSs, and to individualize this topic from the current Wildfire DSSs (which are robust frameworks, sometimes of great complexity). PREVAIL DSS-FM aims to minimize complexity by being direct and accurate, and by firstly addressing the fundamental locations for fuel treatment in a certain area of interest, and thereafter, by applying fire behavior simulators and expanding those locations according to stakeholder objectives and decisions. Hence, the target territory is analyzed as a holistic system where existing planning, management and stakeholders' perspectives are considered and integrated with landscape needs.

To mitigate and overcome the previously mentioned limitations and barriers of DSSs, the DSS proposed here incorporates economic, social, and ecological goals into landscape management and includes cross-scale stakeholders that represent these different perspectives, along the DSS development and as end-users to test the DSS efficiency and validity. For example, one objective of stakeholder participation is to raise awareness about potential goal conflicts among stakeholders, e.g., private and public organizations. An identification of the stakeholder community and their management goals should therefore be carried out in the initial stage of the planning process (Kašpar et al., 2018).

PREVAIL DSS-FM is intended to be a road map for a methodology defined for all territories and conditions, based on a set of rules and dependent on stakeholder engagement.

It is structured into three fundamental sections and inherent questions, as follows:

1. The NEED for fuel management: Is there a need for fuel management?
2. The DIAGNOSTIC for fuel management: Where to treat?
3. The ACTIONS for fuel management: How and when to treat?

The three sections are sequential, as each section depends on the previous one. Therefore, it is mandatory to start in section 1, so that the DSS can be adequately used.

PREVAIL DSS-FM is built on data that is comprehensively described and on results that are produced at each step (outputs) according to the guidelines, thus it can be applied in all territories.

3.2. ROADMAP OF PREVAIL DSS-FM

The conceptual model of PREVAIL DSS for Fuel Management is shown in Figure 3. Each step of this model (roadmap) is described in detail in the following sections.

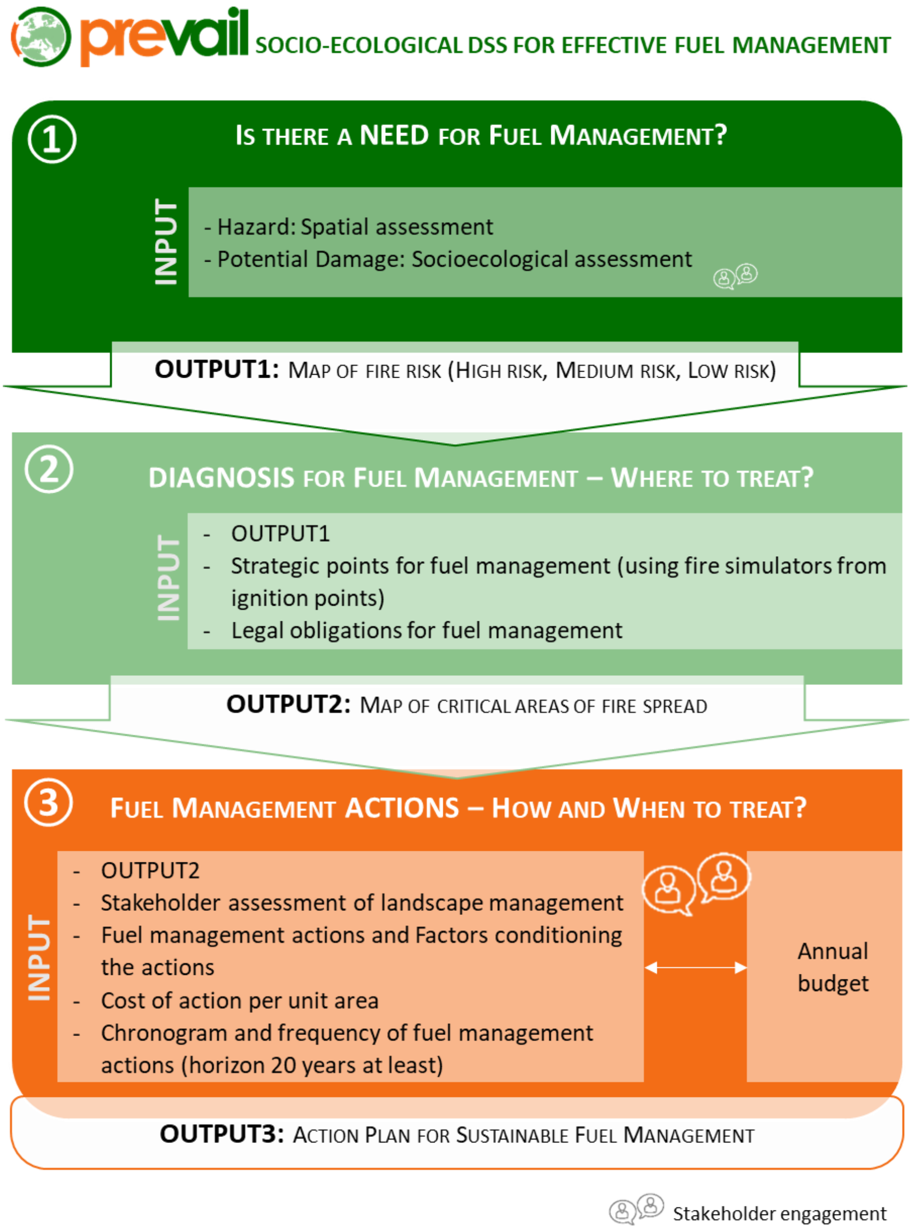


Figure 3. Roadmap of PREVAIL Decision Support System for Fuel Management.

3.3. Guidelines to Follow the Roadmap of PREVAIL DSS-FM

3.3.1. Is there a need for fuel management?

➢ **Definition of the need for fuel management**

The need for fuel management is based on the fire risk identified for the target area. According to Rego & Colaço (2013), risk and potential damage are defined as below. Other risk definitions and formulas may be used, such as the one by UN Office for Disaster Risk Reduction (UNDRR), 2017, available at https://www.preventionweb.net/disaster-risk/risk/disaster-risk/, in which risk is a function of hazard, exposure and vulnerability.

Risk = Hazard x Potential damage

Potential damage = Element at risk x Recovery time

The intersection of the Hazard Map and the Potential damage Map will give the **Map of Fire Risk (OUTPUT1 of the DSS)**, which is represented by a spatial matrix with 3 classes of need: "High risk", "Medium risk", and "Low risk", in which the "Medium risk" is cost dependent.

Table 3. Spatial matrix with "High risk", "Medium risk", and "Low risk" classes. The number of classes shown for the spatial assessment is based on the Portuguese hazard map. However, it may be adapted to a specific territory, independently of the scale of analysis.

		HAZARD: Spatial assessment					
		0: Null	**1: Very low**	**2: Low**	**3: Medium**	**4: High**	**5: Very high**
POTENTIAL DAMAGE: Socioecological assessment	**0: Null**	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
	1: Very low	Low risk	Low risk	Low risk	Low risk	Medium risk	Medium risk
	2: Low	Low risk	Low risk	Medium risk	Medium risk	Medium risk	Medium risk
	3: Medium	Low risk	Low risk	Medium risk	Medium risk	High risk	High risk
	4: High	Low risk	Low risk	Medium risk	High risk	High risk	High risk
	5: Very high	Low risk	Medium risk	Medium risk	High risk	High risk	High risk
							Medium risk is cost dependent

➢ STEPS TO QUANTIFY HAZARD: SPATIAL ASSESSMENT

In many countries in Europe, the spatial need is commonly shown by a map that classifies the territory into distinct areas (spatial polygons) with an ordinal scale of wildfire hazard. For Portugal, for example, the Map of structural fire hazard includes 6 classes (shown in Table 3): 0: Null; 1: Very low; 2: Low; 3: Medium; 4: High; 5: Very high. However, the number of classes used may be adapted to a specific territory, independently of the scale of analysis.

When this type of map or spatial information does not exist for the target area, it is necessary to quantify the hazard based on distinct spatial data, namely:

1. *Terrain slope* or calculation of the slope based on DEMs (e.g., using the ASTER Global Digital Elevation Model (GDEM) Version 3 (ASTGTM), with approx. 30m resolution, available at https://lpdaac.usgs.gov/products/astgtmv003/).

2. *Fuel models or land cover* classification (from land cover maps or satellite data) (e.g., CORINE Land Cover, available at https://land.copernicus.eu/pan-european/corine-land-cover).

It is also necessary to define thresholds for hazardous slopes, for fuel models, etc. The spatial assessment will be a function of all the parameters used, and then ranked into several classes of hazard.

$$\textbf{\textit{Hazard Map}} = f(Fuel\ models, Slopes, etc.)$$

The PREVAIL DSS-FM, being targeted for fuel management, addresses hazard (spatial assessment) for a subset of possible LULC vegetation classes or fuel model types that can be affected by wildfires in the AoI (e.g., forest/shrubland/agricultural land).

➢ Steps to quantify Potential damage: Socioecological assessment

The quantification of the potential damage will identify the socioecological need as shown in Figure 4.

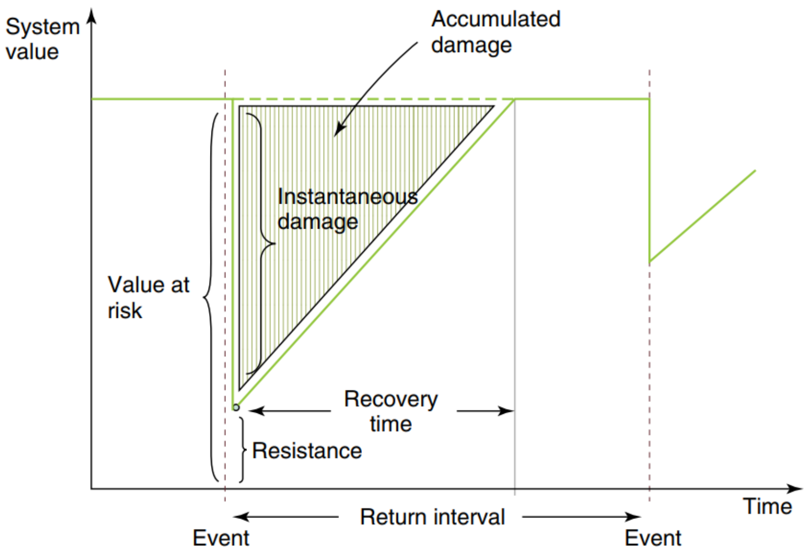


Figure 4. Potential damage and elements at risk. Retrieved from Rego & Colaço (2013).

To calculate the potential damage for the target territory, it is necessary to identify and intersect the following data:

1. *Elements at risk* (i.e., the priority infrastructures network), defined as the total potential loss due to an adverse event (e.g. people, houses, trees) (Rego & Colaço, 2013),

2. *Vulnerability*, which is the fraction of the element at risk damaged instantaneously (Rego & Colaço, 2013),

3. *Socio-ecological value*, defined as the market value of the item (house, infrastructure…) multiplied by the value perceived by the society of the same item (e.g., historical heritage) multiplied by the intrinsic value of the item or ecological service of the item (e.g., plant or animal in the red list, riparian forest, etc.). The value can be quantified in euros when it is a tangible value, or in a scale (qualitative) when intangible. This can be achieved through a Focus Group where experts/stakeholders can express their opinion, defined as a belief or judgment about something,

4. *Recovery time,* defined as the recovery rate of the system that is necessary for it to achieve the state prior to the event (Rego & Colaço, 2013). A special case may be recognized when there can be no recovery of a, often unique, damaged value (e.g., a flammable historical heritage building that is destroyed, an endangered plant or species lost).

$$\textbf{\textit{Potential damage Map}} = f(Values\ at\ risk)$$

$$\textbf{\textit{Elements at risk}} = f(Vulnerability, Socioecological\ value, Recovery\ time)$$

The Elements at risk and corresponding classification must be identified with stakeholder engagement (see section 4). Elements at risk may include:

- critical infrastructure key resources such as agriculture and food, communication, energy, technology and information, transportation, water, and others (touristic areas and historical heritage),
- infrastructure related with the fire and emergency services (e.g., firehouse, police headquarters, water points), vulnerable population (e.g., elderly homes, schools, hospitals),
- forest stands with production purpose,
- high value ecological areas such as Natura 2000 Sites, areas with erosion potential (sensitivity areas), water quality (water collection catchments), forest sensitivity (non-fire-adapted vegetation, recently burned areas), parks and other unique areas.

Forest stands offering protection against floods, mudslides, snow avalanches, etc., must also be checked with stakeholders to apply a multi-risk mitigation.

The identification and classification of all elements at risk for the target area will result in a spatial data layer with the location of the areas, lines, or points with different classes of priority. The number of classes of potential damage depends on the target area, scale of analysis and stakeholders involved. For Portugal, we identified 5 classes for the elements at risk, based on their vulnerability, socio-ecological value, and recovery time, namely: 1: Null; 2: Very low; 3: Low; 4: High; 5: Very high.

3.3.2. THE DIAGNOSTIC FOR FUEL MANAGEMENT: WHERE TO TREAT?

After assessing the need for fuel management, it is necessary to define where to treat. The intersection of the Map of Fire Risk (using high risk and medium risk areas, OUTPUT1) and the Strategic points for fuel management will give the **Map of Critical Areas of Fire Spread (OUTPUT2 of the DSS)**.

- **STEPS TO IDENTIFY THE LOCATIONS FOR FUEL MANAGEMENT**

To find the locations where fuel management should be carried out, it is necessary to intersect the following spatial data:

1. *Map of fire risk*, which is the output of the previous section (OUTPUT 1). Here only High risk and Medium risk areas are to be used,

2. *Strategic points for fuel management*, defined as spots that may increase fire spread rate, intensity, severity, and/or create new fire fronts. These areas are drawn using fire

simulators from ignition points. If there are no historical ignition points available, random points distributed along the road network may be used (Catry et al., 2010). A description and availability of the most used fire simulators is given in section 2.1.,

3. When possible, *information on historical fires, their typology and behavior* should be included.

After the locations for fuel management are found, *Legal Obligations for performing fuel management in the area of interest (AoI)* must be considered. It is necessary to check if there are any fuel management legal obligations to meet in the AoI. Legal obligations are for instance, the Forest Fire Defense network in Portugal, which is a set of Mandatory Areas for Fuel Management in areas surrounding settlements and infrastructure, conceived to protect people and key infrastructures, from the Civil Protection point of view. These mandatory areas are considered at this stage from a more technical point of view of where fuel management should be carried out. Nevertheless, these mandatory areas for fuel management should be carefully analyzed by stakeholders in the following section, within "stakeholder assessment of landscape management".

3.3.3. THE ACTION OF FUEL MANAGEMENT: HOW AND WHEN TO TREAT?

- **STEPS TO DEFINE HOW TO TREAT**

How to treat is an **Action plan for sustainable management (OUTPUT3 of the DSS)** of the target area. It comprehends the fuel management actions to be carried out at the priority areas for fuel management identified in the previous steps, as well as their frequency, the management goals of the different stakeholders and their synergies (potential smart solutions for fuel management). The Action plan will be defined by the combination of the following data:

1. *Map of Critical Areas of Fire Spread* (this is the output of the previous section – OUTPUT2),

2. *Stakeholder assessment of landscape management*, which is based on stakeholder engagement (see section 4 – Focus Group). Existing fire and forest management plans, land tenure information and relevant stakeholder fuel management goals for the AoI will be integrated and discussed, in order to identify conflicts, tradeoffs and synergies concerning stakeholder´s goals, tactics and decisions. This information is crucial to assess fuel management actions. Legal Obligations for performing fuel management in the AoI must be considered and discussed at this point among stakeholders,

3. *Fuel management actions and factors conditioning the actions*. An example of these actions is shown in Table 4.
   Every action to manage fuel will have its own demands, constraints, and characteristics. For instance, when using heavy machinery, it is necessary to have a good logistic to transport the dozer to the area of intervention, have a certified driver, the slope cannot be too steep, etc.

Prescribed burning (PB) also has its own demands and constraints, such as a PB plan, certified technicians, the meteorological window of opportunity, type of fuel, etc. Some constraints may also occur when the fuel management is next to a highway or hospitals due to the smoke it produces. For a sound decision about the most appropriate actions to implement, it is important that the manager is aware of the different techniques and their pros and cons (see Table 4),

4. Cost of action per unit area, which is an application of previously defined market values to the target area. The cost of each action is based on the cost per unit (e.g., EUR per hectare) multiplied by the total area where that specific action will take place. In Portugal, many of these costs are given in specific governmental tables (Cost of forest operations, CAOF, periodically updated by the ICNF, available at www.icnf.pt/florestas/arborizacoes/caofcustosdeoperacoesdearborizacao). If this information is not available for the AoI, it should be collected from the Focus Group (see section 4) or/and from the literature or asking for activity quote to service providers. A table as shown in Table 5 may be built using this information.

Table 4. Example of a Matrix of solutions for Fuel Management actions. Conditioning factors and their characteristics must be adapted to each AoI. Examples are given in some cells.

					Factors conditioning the actions				
					Smoke	**Slope**	**Meteorology**	**Land cover**	**Etc.**
FM Actions	**Business as usual**	**Machinery**							
		Heavy machinery						E.g., protected areas	
		Prescribed burning			E.g., highways, WUI		Window of opportunity		
	Landscape integrated management for fire prevention (Smart Solutions)	Agroforestry Management	Livestock husbandry	Sheep					
				Goats					
				Cows					
			Conservation	Wild animals					
			Wood forest products						
			Non-wood forest products	Resin extraction					
				Mushrooms					
		LULC	Change in land use	Agriculture					
				LULC mosaics					
				Aromatic shrubs, etc.					

Table 5. Possible Fuel Management actions selected in the previous step.

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="2">Cost of action</th></tr>
<tr><th>EUR per hectare</th><th>Cost</th></tr>
<tr><td rowspan="5">Actions selected</td><td>Machinery</td><td></td><td></td></tr>
<tr><td>Heavy machinery</td><td></td><td></td></tr>
<tr><td>Prescribed burning</td><td></td><td></td></tr>
<tr><td>Etc. (other fuel management actions selected in previous steps)</td><td></td><td></td></tr>
<tr><td>Combination of techniques</td><td></td><td></td></tr>
<tr><td colspan="2">Total</td><td></td><td></td></tr>
</table>

- **STEPS TO DEFINE WHEN TO TREAT**

In addition to the data previously mentioned in “How to treat”, information on the timing of the actions must be explicit in the Action plan for sustainable management. This action plan will be defined for a horizon of 20 years in a ***Chronogram and frequency of fuel management actions (20 years period).*** We considered 20 years as a comprehensive period that is needed for a continuous and re-evaluation assessment of fuel actions, in order to guarantee its success.

- **BUDGET FOR FUEL MANAGEMENT**

In order to not constrain the implementation of the proposed Action plan for sustainable management over the years, the annual budget for fuel management for the AoI must be very explicit in this document and take into consideration the prospective prices (taking into account the inflation impact).

4. Development of the Focus Group: how to carry out stakeholder engagement?

4.1. The importance of the focus group

The focus group is a very important part of a DSS, and it represents nearly a quarter of the work to be done. A Focus Group discussion is “a technique where a researcher assembles a group of individuals to discuss a specific topic, aiming to draw from the complex personal experiences, beliefs, perceptions and attitudes of the participants through a moderated interaction” (Nyumba et al., 2018, p. 21). Figure 5 presents a flow chart of the steps of the focus group discussion technique.

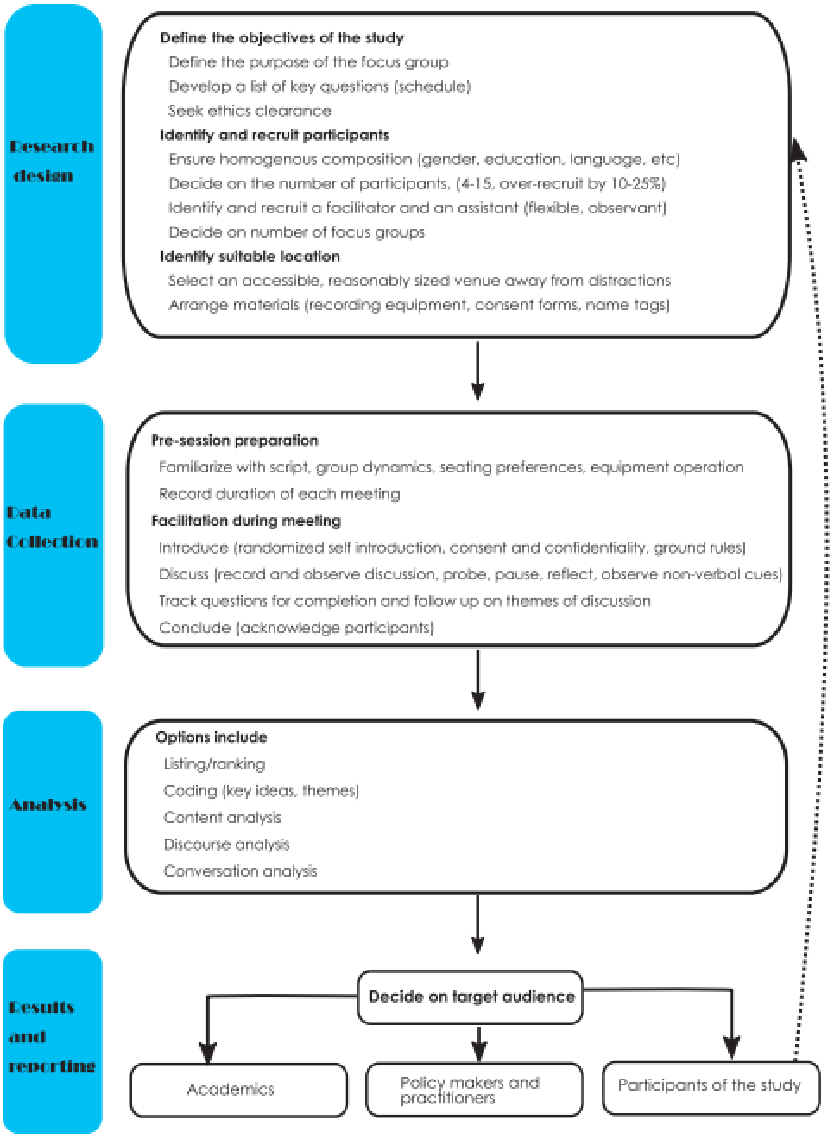


Figure 5. Flow chart of the steps of the focus group discussion technique. Retrieved from Nyumba et al. (2018).

4.2. STAKEHOLDER ENGAGEMENT AND SELECTION

Stakeholder engagement in PREVAIL DSS-FM will be done with focus group methodology and has two main objectives. The first objective of the focus group is to create a list and respective ranking of priorities of the elements at risk for the area of interest (AoI). Stakeholders will contribute to decide more in-depth which are the elements at risk in their AoI, and which classification of vulnerability, value and recovery time should be attributed to each of the elements at risk selected. The second objective is to contribute to assess landscape management, and to select the most suitable fuel management actions and treatment timings, having in consideration the specificities of the AoI.

Relevant stakeholders for the AoI should be identified and selected from entities in charge of fuel management interventions and fire prevention within that AoI. The following criteria should be used for the selection of the stakeholders (along with some examples):

- Local level: Public and private landowners with areas > 5 ha, Municipalities,
- Landscape/regional level: NGOs, Organizations of Forest Producers, Commoner's land, Intermunicipal Commissions, Governmental Regional Delegations,
- National level: Communication, Energy, Technology and information, and Transportation sectors, Nature conservancy and Forest Authority, Civil Protection Authority,
- Others, such as leaders from communities from the AoI and surroundings, who may have different or additional proposals for fuel management towards a more integrated landscape management.

4.3. PREVAIL DSS-FM FOCUS GROUP STEPS

Besides the invited participants, there will be a moderator who will present the methodology to be employed during the focus group, guide the participants across the several steps, and promote the discussion among stakeholders. The moderator will also ensure that the comments of all participants are considered to reach a consensus that is required to progress along the DSS.

There will be also a presenter who explains the DSS (roadmap and several steps) and supports the moderator with the technical data that is necessary for the focus group. If possible, the team that conducts the focus group should also have a "secretariat" who will take notes of all the discussion and help the moderator guiding the focus group.

The focus group should start with the identification and presentation of all participants. The moderator and PREVAIL team will then present the agenda, objectives and the DSS. In the following steps, we will present general guidelines on how to carry out stakeholder engagement to assess the various steps of the PREVAIL- DSS.

- **ASSESSMENT OF ELEMENTS AT RISK BY THE STAKEHOLDERS**

To assess the elements at risk, the following materials need to be prepared in advance: (i) a preliminary list of elements at risk, and (ii) a table to be filled with the rankings for each category (see Table 6). A map with high LULC resolution for the AoI can also be provided for visualization of the spatial location of aerial/line features associated with the elements at risk.

The table to be filled with the rankings can be provided as an excel spreadsheet. Each participant will be asked to fill his/her own table, individually, according to the following steps:

1) A preliminary list of elements at risk in the AoI is presented to the participants and may be completed with new elements at risk proposed by the stakeholders,
2) Next, stakeholders are asked to classify each element at risk according to its vulnerability to fire, previously defined as the percentage damaged in case of fire occurrence and classified in a scale from 0 to 4 (0: No damage; 1: 25% damaged; 2: 50% damaged; 3: 75% damaged; 4: Value destroyed),
3) Participants will also need to assess the ecological and socioeconomic value of each element at risk. The value can be quantified in euros if it is a tangible value, or according to a scale (1: Low value to 4: Very high value) if intangible,
4) Finally, participants should classify the likelihood of the recovery time in a scale from 1 to 4 (1: less than 1 year to recover; and 4: a long time to recover completely, or very high difficulty to reach the prior state before the fire),
5) The final value will be given by the multiplication of all the previous classifications.

Finally, after all the 5 steps are performed individually, the information is gathered by the management team and results are presented to be discussed among stakeholders, in order to reach a consensus on vulnerability, socioecological value, recovery time, and a final ranking for all elements at risk identified. This information will then be converted into the Map of Potential Damage.

During all these steps it is important that the moderator or member of the management team to has knowledge on the impacts of wildfires on the vegetation and vegetation strategies/mechanisms to recover after a fire (when applicable).

Table 6. Final ranking of elements at risk according to stakeholders.

Steps	**1st: list the name of the elements at risk**	**2nd: classify their vulnerability**	**3rd: classify their socio-ecological value** (classify separately and sum the two values)		**4th: classify their recovery time**	**5th: calculate final value**
	Element at risk	**Vulnerability**	**Ecological value**	**Socio economic value**	**Recovery time**	**Final value**
Scale	N/A	(0 - 4)	(1 - 4)	(tangible or intangible) EUR or (1 - 4)	(1 - 4)	Multiply all previous classifications

- **Stakeholder assessment of landscape management: looking for synergies and smart-solutions**

- Explanation of the importance of the landscape integrated management, and presentation of PREVAIL framework on that concept, namely, PREVAIL Deliverable 4.2 – Report on wildfire risk management lessons learnt and fuel management smart solutions selection.
- Presentation of existing forest and fire management plans across scales and relevant stakeholders fuel management goals for the AoI.
- Identification of management plans that are missing from above.
- Collection of knowledge and opinions on the various plans presented (with the help of forms).
- Identification and discussion of synergies, tradeoffs, and opposing management goals among stakeholders; results should be included in the Map of FM actions.
- Identification of legal obligation for fuel management in the AoI. The legal obligations, depending on the country, may be set by law, by Civil Protection or other entity, or may not exist at all. If they do not exist, their necessity may be discussed.

- **Stakeholder assessment of fuel management actions, factors conditioning the actions and costs**

The PREVAIL team will present the list of business-as-usual techniques for fuel management and the smart solutions gathered during the previous step of the focus group, using a table like Table 4. Questions will be raised on the knowledge of these alternatives, and on missing actions that are not included on the table, in order to fill in the cells and improve the table. Feasibility of these actions in the AoI will also be discussed among participants.

Stakeholders will also be asked to quantify and discuss the cost of each action, in order to build a Matrix of budgeted solutions for Fuel Management for the AoI like Table 5, based on the final list of actions previously defined.

- **Stakeholder assessment of the Chronogram and frequency of fuel management actions**

In order to be effective, fuel management needs to be performed in phases and during a long-term period. Also, not all activities can be done at the same time. There are meteorological constraints like fire risk season or the PB window of opportunity. Depending on the area to be treated, there are biological specificities like birds and mammals breeding season, etc.

Vegetation growth depends not only on the species but also on the region of the AoI. For instance, at a certain area, fuel management can be done every 10 years, but at another area, fuel maintenance may be necessary every 3 years.

During the focus group, a table with a chronogram for each FM action and plot (single areas to be treated) within the AoI will be presented and discussed so that stakeholders may give their input and improve the table (Table 7).

Table 7. Chronogram by plot for each action.

AoI	Technique to be used	1st intervention (date)	2nd intervention (date)	3rd intervention (date)	4th intervention (date)	5th intervention (date)	Etc.
Plot1							
Plot2							
Plot3							
Etc.							

- **STAKEHOLDER FINAL ASSESSMENT**

A final assessment of the presented DSS should be done in order to gather participants' opinions about its utility, feasibility and user friendliness.

5. Application of PREVAIL DSS-FM to a Portuguese case study: municipality of Cascais

5.1. Area of interest

The Municipality of Cascais is in western Portugal, about 30km northwest of Lisbon and has a total area of 9740 hectares. A wildfire occurred in the northwestern part of this municipality on October 6th, 2018, inside the Natural Park “Sintra-Cascais” (Serra de Sintra was classified as World Cultural Heritage Site by UNESCO in 1995), with a burned area of 428 hectares of mainly shrubland land cover. The fire started at 10:50pm and was active for 11h55m, when it was brought under control by the firefighting teams. It was extinguished on October 7th, at 2:27pm, and the mop up was finished on October 11th. Despite no deaths were registered, there were significant impacts due to its location, very close to three urban settlements (Malveira da Serra, Charneca and Aldeia de Juso). There were nearly 2 dozen people injured, and more than 300 people were evacuated from hazard locations.

The Municipality acted after the fire and started studying how to change the landscape in the northwestern region of Cascais in order to increase resilience to future forest fires (“landscape change project”). Since there is a strong will to change, this is a very interesting case study to apply the PREVAIL DSS-FM and validate it with the stakeholders involved. We will use the area of interest (AoI) identified by the Municipality of Cascais in their “landscape change project” (Figure 6).

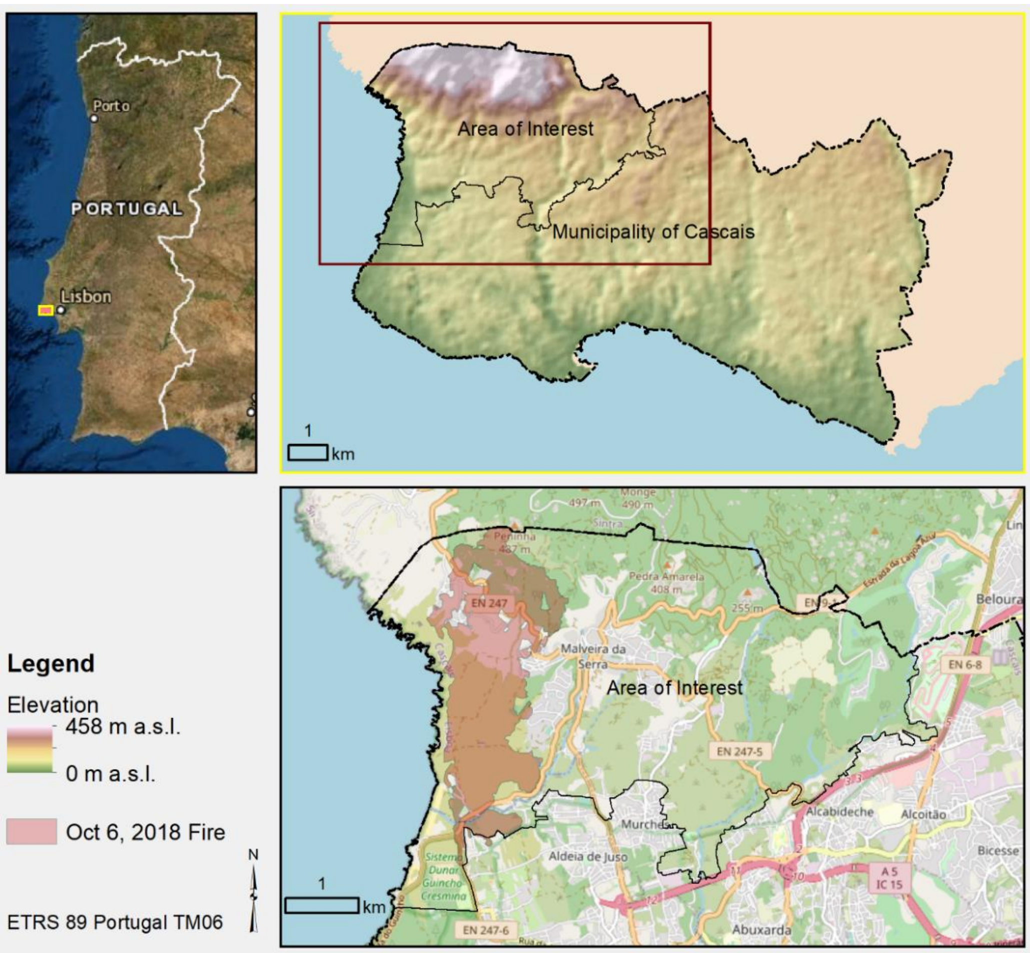


Figure 6. Area of Interest (AoI) located in the Municipality of Cascais.

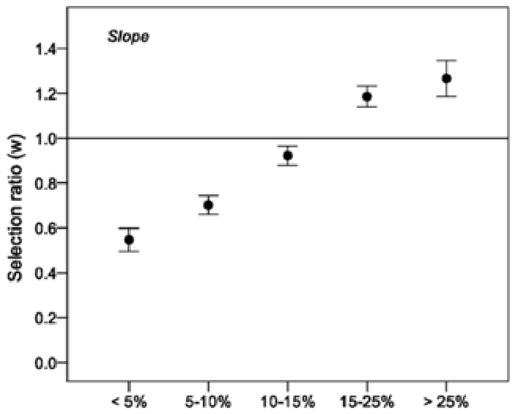
5.2. Is there a need for fuel management?

➢ **Definition of the need for fuel management**

➢ **Hazard: Spatial assessment**

In order to assess hazard, we used the Map of Slopes and the Map of Land cover. Both were reclassified according to the fire selection ratios found in Carmo et al. 2011, Moreno et al. 2011, and Oliveira et al. 2014 (see Figure 7). In EU countries where this information is missing, fuel flammability index (see PREVAIL Deliverable 3.2 – Statistical analysis) can be used instead.

- The *Map of slopes* was obtained from the Digital Terrain Model, spatial resolution 30m (ESRI-Portugal, available at https://www.arcgis.com/home/search.html?t=content&q=owner%3AESRI-PT). We adopted the same thresholds as Carmo et al. (2011). Then, we reclassified this map to identify which slopes are more hazardous, according to Figure 7.



Slope threshold	Reclassification value for the AoI
0-5%	0,5
5-10%	0,7
10-15%	0,9
15-25%	1,2
>25%	1,3

Figure 7. Average selection ratio (w) with 95% confidence intervals for slope in Northern Portugal (retrieved from Carmo (2011, p. 172, Fig.2)*, and reclassification value used for each slope threshold for the AoI.*

- The *Map of LULC* was obtained from the LULC (land use land cover) map for Portugal for the year 2018 (COS2018, minimum cartographic unit of 1 hectare, with 83 classes of LULC, available at https://www.dgterritorio.gov.pt/Carta-de-Uso-e-Ocupacao-do-Solo-para-2018). We reclassified this map in order to identify which land covers are more hazardous, according to the Portuguese National Strategy for Forests (ICNF, 2014), Figure 8. The reclassification follows the fire incidence rate by forest land cover in Portugal. Urban and coastal areas with no fuel to burn were classified with 0.

- Pinheiro-bravo (2,33)
- Outras resinosas (2,63)
- Eucaliptos (2,03)
- Sobreiro (0,58)
- Azinheira (0,31)
- Pinheiro-manso (0,40)
- Castanheiro (0,68)
- Carvalhos (0,68)
- Outras folhosas (2,36)
- Acácias (1,68)
- Alfarrobeira (0,03)
- Matos (2,54)

Land cover class	Reclassification value for the AoI
Acacia	1,68
Eucalyptus	2,03
Pinus pinaster	2,33
Pinus pinea	0,40
Quercus ilex	0,31
Quercus suber	0,58
Other hardwoods	2,36
Other softwoods	2,63
Other oaks	0,68
Shrubland	2,54
Agriculture	0,30

Figure 8. Fire incidence rate by forest land cover. Extract from ICNF (2014, p. 34, Fig.13)*, and reclassification value used for each forest land cover for the AoI.*

- The *Hazard Map*, Figure 9, was obtained by the multiplication of the previously reclassified Map of Slopes and Map of LULC. Then, we removed value = 0, and we reclassified this new generated map into 5 classes, using the quantile approach. The quantile approach is a data classification method that distributes a set of values into groups that contain an equal number of values (i.e., total nr. observations per class = total observations / nr. classes). A division into quintiles (5 quantile classes, as proposed) shows exactly 20% of the observations at each class. In this case, the hazard classification by quintiles should place 20% of the pixels in each hazard class. Even if exactly 20% of the pixels are not observed in each class, the use of quintiles is recommended for being an exempt classification (AFN-ICNF, 2012). The 5 classes of fire hazard used were “Very low”, “Low”, “Medium”, “High”, and “Very high”.

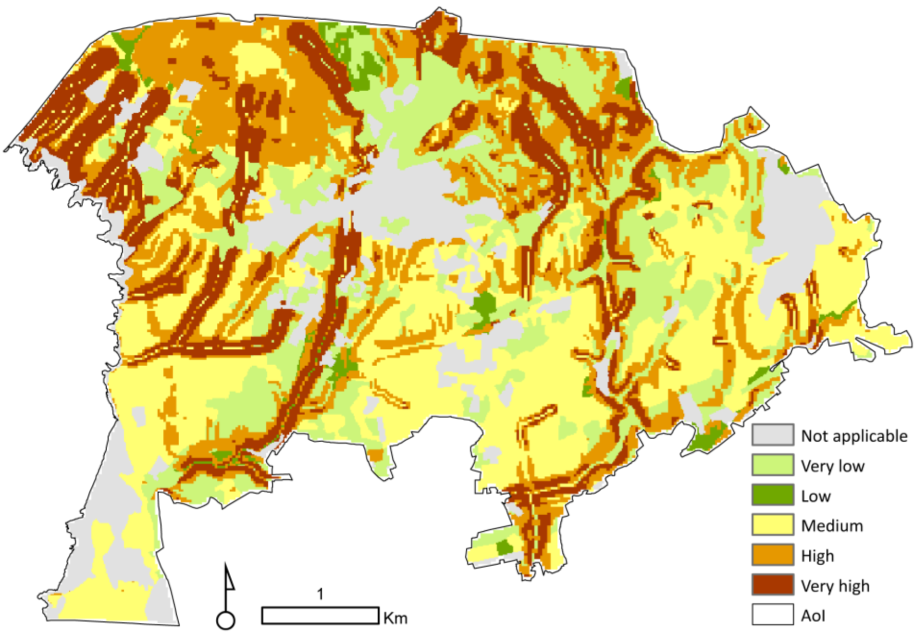


Figure 9. Map of hazard - Spatial assessment for the AoI. Scale 1:50.000. Settlements are classified as “not applicable” because they do not have fuel to burn.

➢ **POTENTIAL DAMAGE: SOCIOECOLOGICAL ASSESSMENT**

To assess the potential damage, we need a list of the Elements at risk, and their (i) vulnerability value, (ii) Socio-ecological value, and (iii) Recovery time. As previously explained, these are attributed to each element at risk identified.

Stakeholder's engagement is mandatory to create the layer of the *Elements at risk*, in order to classify them according to:

- *Vulnerability to fire*, i.e., the percentage damaged in case of fire occurrence, classified for each element at risk, using values from 0 to 4.

- *Socioecological value*, i.e., a classification that reflects the ecological or socioeconomic values of the element at risk, attributed to each element at risk. The Municipal Plan for the Forest Fire Defense of Cascais attributes economic values to each element at risk, as shown in Table 8 (only forest LULC are included in the Plan). Since we do not have tangible numbers for all the elements at risk selected, we used a scale from 1 to 4 for the socioecological value, where 1 represents low value and 4 very high value.

Table 8. Elements at risk, vulnerability, and value, according to the Municipal Plan for the Forest Fire Defense of the Municipality of Cascais. Adapted from Câmara Municipal de Cascais (2020, p. 151).

Element at risk		Vulnerability	Value (tangible)
Forest	Agroforestry	0,50	150 €/ha
	Other oaks	0,60	1087 €/ha
	Eucalyptus	0,80	1125 €/ha
	Invasive species	1,00	0 €/ha
	Other hardwoods	0,50	1507 €/ha
	Pinus pinaster	1,00	1480 €/ha
	Pinus pinea	1,00	1553 €/ha
	Other softwoods	1,00	1400 €/ha
	Shrubland	0,40	52,5 €/ha

- *Recovery time of each element at risk*, i.e., a classification that reflects the recovery time in case of fire occurrence, attributed to each element at risk. For this example, we used a rank 1-4 (value 1 represents less than 1 year to recover and value 4 represents a long time to recover completely or high difficulty to reach the prior state before the fire).

Table 9 is a draft of the elements at risk for the AoI, as well as the values for vulnerability, socioecological value, and recovery time, to be discussed in the focus group. These draft values were used as a test for this case study and were based on a simple evaluation by ISA team. A buffer around urban areas may also be considered as a WUI element at risk, since wildfire spotting of 100 meters may be important (Alexandrian, 2002).

Table 9. Elements at risk in the AoI.

<table>
<tr><th colspan="2">Element at risk</th><th>Vulnerability</th><th>Socio-ecological value</th><th>Recovery time</th></tr>
<tr><td>Communication</td><td>- Very high voltage energy transmission network
- High voltage energy transmission network
- Energy transmission network</td><td colspan="3" rowspan="6">Mandatory for Portugal. It is already included in the forest fire defense network, thus, for this exercise they were overlayed to the risk map and classified as “mandatory areas for fuel management” in Figure 11.</td></tr>
<tr><td>Energy</td><td>Gas transmission network</td></tr>
<tr><td>Technology and information</td><td>Telecommunication network</td></tr>
<tr><td>Transportation</td><td>- Road network
- Railway network</td></tr>
<tr><td>Water</td><td>Firefighting water points</td></tr>
<tr><td colspan="2">Fire lookout points</td></tr>
<tr><td>Touristic areas and historical heritage</td><td>Sintra-Cascais Natural Park (SCNP)</td><td colspan="3">The SCNP is already considered above, within the protected area</td></tr>
<tr><td rowspan="2">Agriculture and food</td><td>Agriculture</td><td>2</td><td>3</td><td>2</td></tr>
<tr><td>Pastures</td><td>2</td><td>2</td><td>2</td></tr>
<tr><td rowspan="5">Areas with conservation status</td><td>SCNP Protected area – Areas Full Protection</td><td>4</td><td>4</td><td>4</td></tr>
<tr><td>SCNP Protected area – Areas Type I</td><td>3</td><td>4</td><td>3</td></tr>
<tr><td>SCNP Protected area – Areas Type II</td><td>3</td><td>4</td><td>3</td></tr>
<tr><td>SCNP Protected area – Complementary Areas</td><td>3</td><td>4</td><td>3</td></tr>
<tr><td>Site of Community Importance - Natura 2000. PTCON0008</td><td>4</td><td>4</td><td>3</td></tr>
<tr><td rowspan="9">Forest</td><td>Agroforestry</td><td>2</td><td>3</td><td>3</td></tr>
<tr><td>Other oaks</td><td>3</td><td>3</td><td>3</td></tr>
<tr><td>Eucalyptus</td><td>3</td><td>3</td><td>2</td></tr>
<tr><td>Invasive species</td><td>4</td><td>1</td><td>1</td></tr>
<tr><td>Other hardwoods</td><td>2</td><td>3</td><td>3</td></tr>
<tr><td>Pinus pinaster</td><td>4</td><td>3</td><td>3</td></tr>
<tr><td>Pinus pinea</td><td>4</td><td>3</td><td>3</td></tr>
<tr><td>Other softwoods</td><td>4</td><td>3</td><td>3</td></tr>
<tr><td>Shrubland</td><td>1</td><td>2</td><td>1</td></tr>
</table>

- The *Map of Potential Damage* was obtained by converting the information on Table 9 to a raster map, in which pixel values are given by multiplying vulnerability, socio-ecological value, and recovery time. The resulting raster was then reclassified using the quantile approach. The 5 final classes of potential damage are “Very low”, “Low”, “Medium”, “High”, and “Very high” (Figure 10). If the socioeconomic value classification mixes monetary values and rankings for the same table, a reclassification of the final socioeconomic values should be performed to also reach the same classes applied to the rankings.

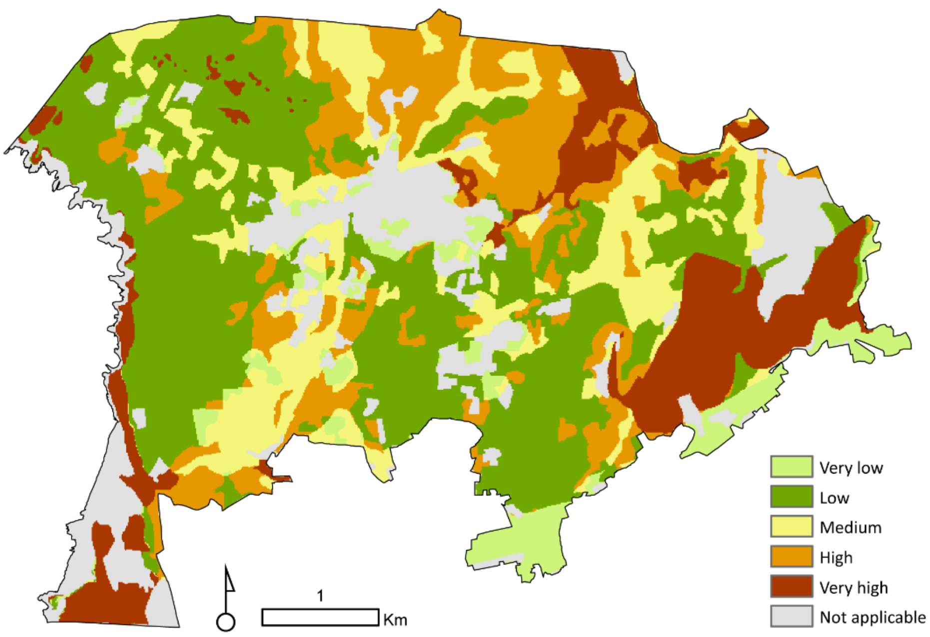


Figure 10. Map of potential damage for the AoI. Scale 1:50.000.

- **OUTPUT1: MAP OF FIRE RISK**

The *Map of Fire Risk*, Figure 11, was obtained by the intersection of the Hazard Map and the Map of Potential Damage. Then, we reclassified the resulting map into 3 classes according to Table 3.

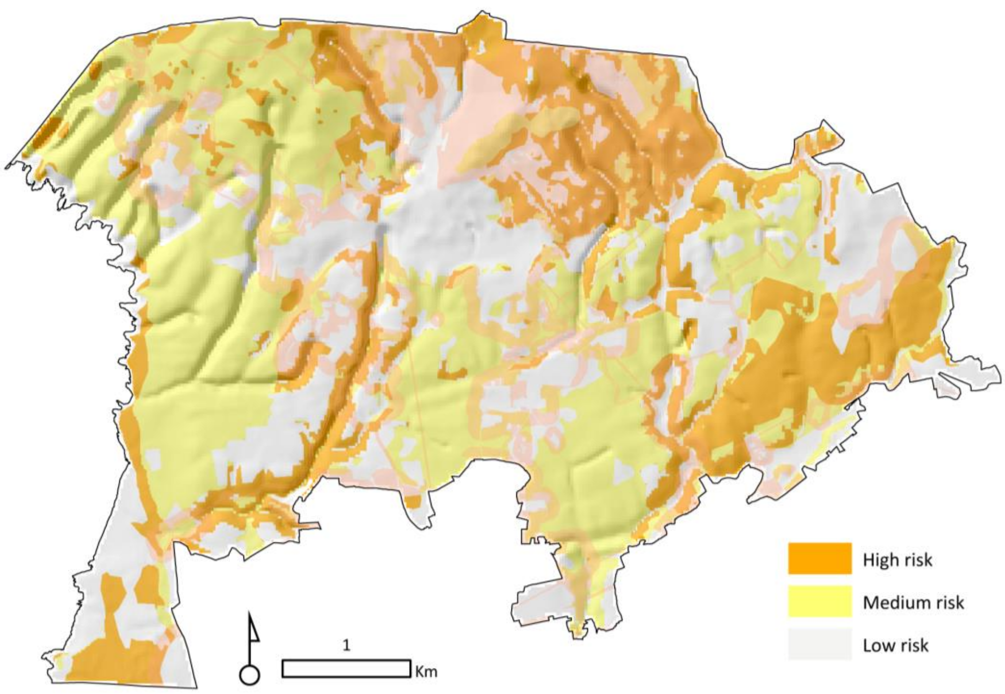


Figure 11. Map of fire risk for the AoI. Scale 1:50.000.

5.3. THE DIAGNOSTIC FOR FUEL MANAGEMENT: WHERE TO TREAT?

➢ WHERE TO TREAT

To identify the areas to treat, we need the Map of Fire Risk (indicating the need for fuel management), and the Strategic points for fuel management (using fire simulators from ignition points). Then we need the Map of Mandatory areas for fuel management.

- *Map of Fire Risk*. This map is the output of the previous section – OUTPUT1.

- To find the *Critical areas for fire spread*, i.e., hotspots that may increase spread rate, intensity, severity, and/or create new fire fronts, we chose the Flammap fire analysis desktop application (available at https://www.firelab.org/project/flammap). Our landscape file input was created using the Elevation Map, Map of Slopes, Map of Fuel Models, Map of Aspect, and the values in Table 10. The maps were obtained from the DEM or made available by the Cascais Municipality.

Table 10. Classification of fuel model parameters according to the latest version of the Portuguese National Forest Inventory – 6th version, yr. 2010. Equations developed by CEABN-ISA team.

Fuel Model		Canopy Height	Canopy Cover	Canopy Base Height	Canopy Bulk Density
1	Annual or perennial pastures	0,30	0,00	0,00	0,00
2	Shrub/herbaceous matrices resulting from frequent fire	0,30	0,00	0,00	0,00
4	Continuous (horizontally and vertically) shrub layer	1,29	0,00	0,00	2,20
5	Dense but low shrubs	0,50	0,00	0,00	2,20
6	Tall and old shrubs	1,50	0,00	0,00	2,20
7	Shrubs of highly flammable species	2,00	0,00	0,00	2,20

Within the Flammap fire simulator, we used the fire ignition points for the period 2001-2019 from the Portuguese forest fires database (SGIF), a 4-hour simulation, and the most reported wind direction (NNW) and speed (15,31mph) in the AoI. For this period, 148 fire ignitions were reported in the AoI (Table 11).

Table 11. Number of ignitions per year (2001-2019) for the AoI.

Year	Number of ignitions	Year	Number of ignitions
2001	9	2011	2
2002	21	2012	1
2003	13	2013	7
2004	15	2014	2
2005	19	2015	6
2006	6	2016	4
2007	9	2017	4
2008	2	2018	4
2009	4	2019	9
2010	11	**Total**	**148**

- *Legal obligation for fuel management – Mandatory areas for fuel management.* The mandatory areas for fuel management in Portugal are included in the Forest Fire Defense Network, which is defined according to the Portuguese legislation (article 15 of Decree Law No 124 of 28 June 2006) and includes the fuel management bands, forest roads and water points. These shapefiles were made available by the Municipality of Cascais. Mandatory areas for FM in the AoI include two types: fuel management bands with a stronger legal obligation, and mosaics, which are shown in Figure 12. Fuel bands are described in Table 12.

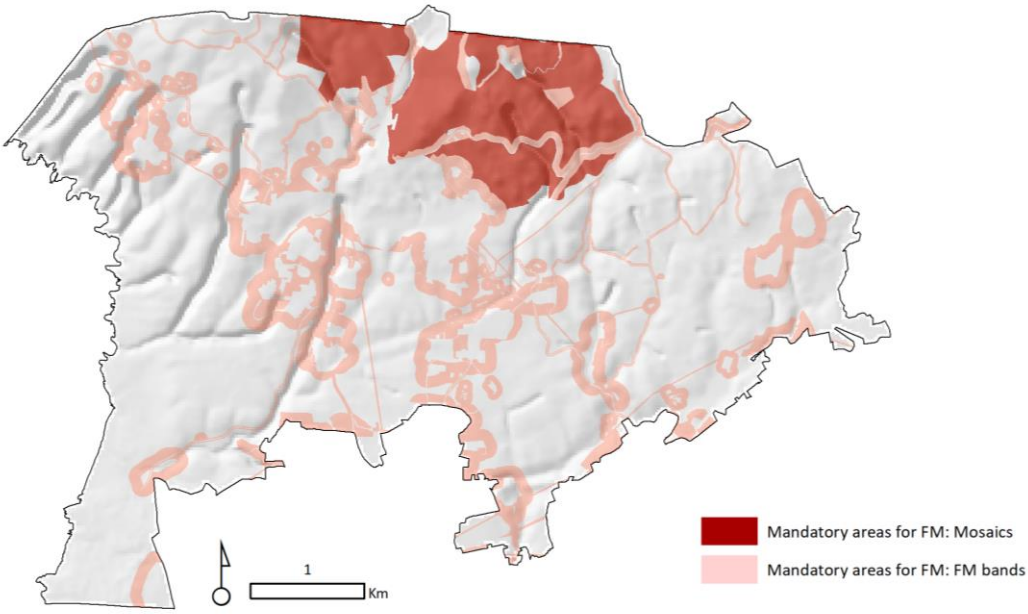


Figure 12. Map of the Forest Fire Defense Network for the AoI. Scale 1:50.000.

Table 12. Fuel management bands description according to the Portuguese legislation (Mandatory areas for FM). Adapted from Câmara Municipal de Cascais (2020, p. 152).

Description	Band width (m)
Constructions within rural areas (buildings, construction sites, warehouses, other construction buildings)	50
WUI areas (10 or more buildings spaced not more than 50 meters)	100
Camping sites and picnic sites	100
Forest road network	10
Gas transmission network	10
Very high voltage energy transmission network	10
Fuel management plot mosaics (agricultural land, inland water, rock outcrops, golf courses, wind farms)	-
Water points	30
High voltage energy transmission network	10

➢ OUTPUT2: MAP OF CRITICAL AREAS OF FIRE SPREAD

The Map of critical areas for fire spread was obtained overlaying the Map of fire risk and the Critical areas of fire spread (Figure 13). From all critical areas obtained, and for this specific example, we selected only the critical areas that fall outside FM mandatory Bands and Mosaics, as the other ones are supposed to be already treated because they are mandatory areas for fuel management. Then, the analysis zooms separately to these new selected areas. We used a 1:10.000, and we present 2 examples of Strategic points for fuel management in Figure 14. These are the smallest interventions that should be performed in these critical areas of fire spread. In the following steps best solutions to enlarge and improve these areas should be formulated and discussed among stakeholders.

In Portugal there are mandatory areas to perform fuel management. For this reason, it is crucial that the manager(s) of these areas is/are included in the focus group and discuss with all the participants which are the best and more sustainable fuel management solutions.

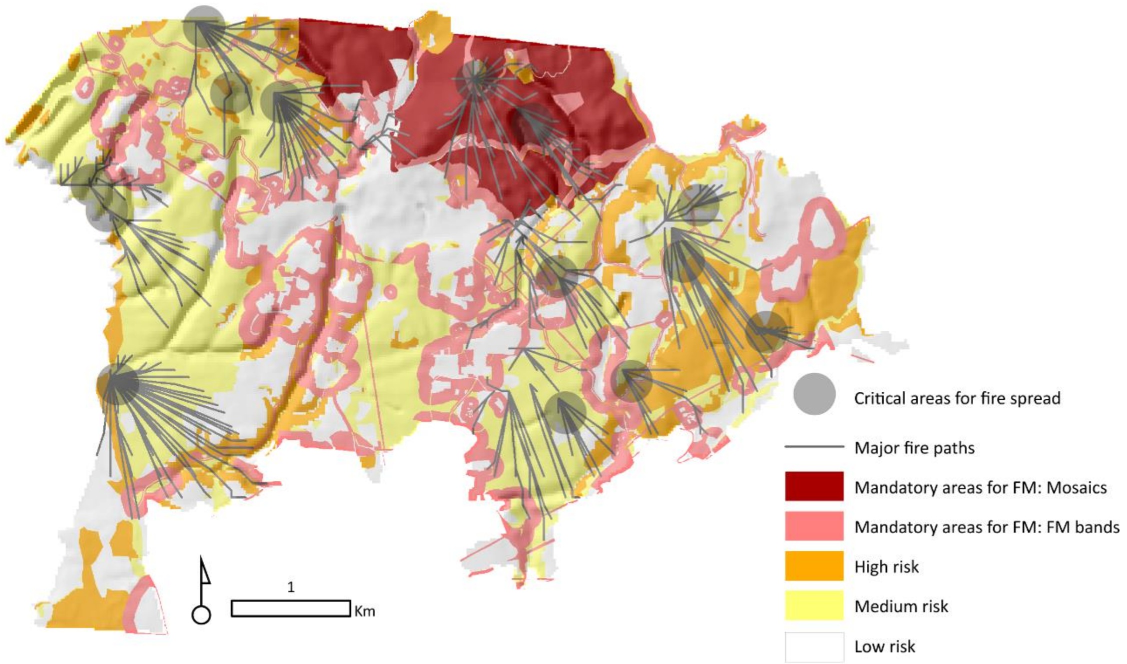


Figure 13. Map of critical areas of fire spread. Scale 1:50.000.

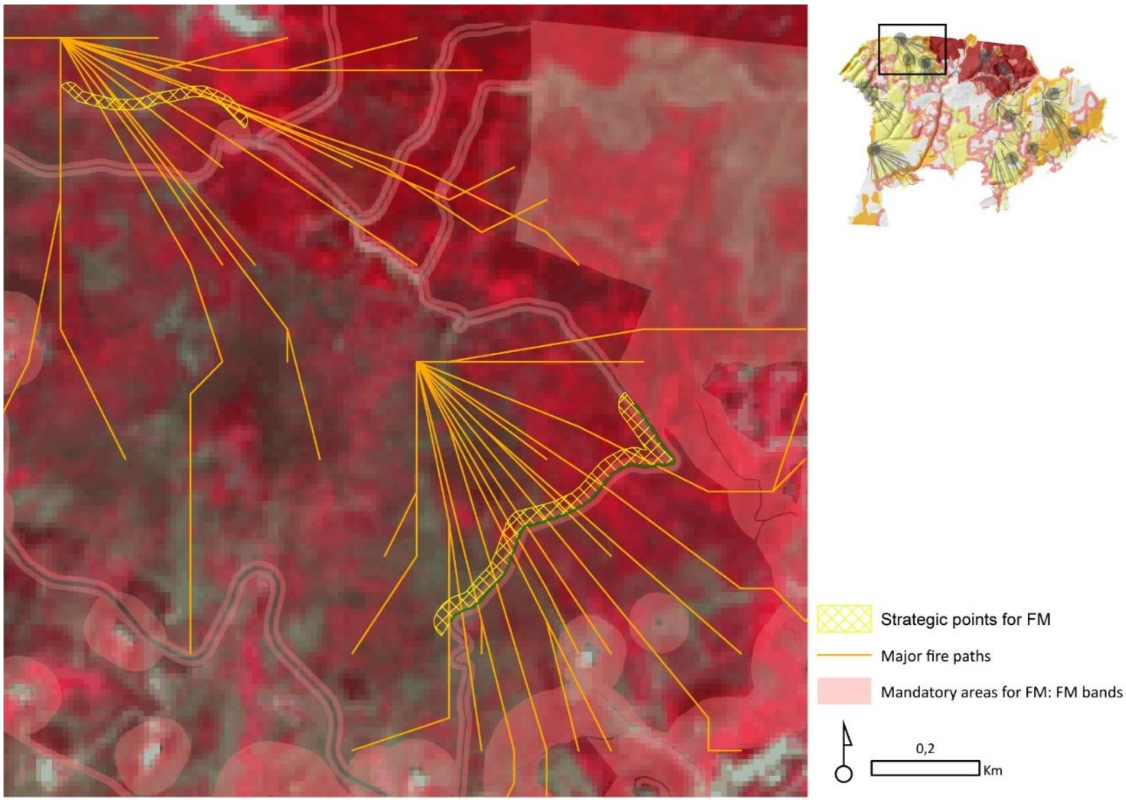


Figure 14. Example of 2 Strategic points for fuel management. The northern strategic point is based on a tiny lane where a corridor of 20 meters was applied; for the southern strategic point, an enlargement of the mandatory corridor was performed adding a length of 20 meters in the direction from which the fire will likely arrive, considering past fire events. Scale 1:10.000.

5.4. THE ACTIONS OF FUEL MANAGEMENT: HOW AND WHEN TO TREAT?

- **HOW AND WHEN TO TREAT?**

To identify how to treat, we need the above-mentioned data in order to obtain the *Action Plan for Sustainable Fuel Management*.

- *Map of critical areas of fire spread*. This is the output of the previous section – OUTPUT2.

- *Stakeholder assessment of landscape management*. For this task, stakeholder's engagement is mandatory. Thus, the necessary information will result from the focus group, where existing fire and forest management plans across scales and relevant stakeholder's fuel management goals for the AoI will be integrated and discussed. Synergies, tradeoffs, and opposing management goals among stakeholders and priority/mandatory areas will be identified. In this process, instruments for territorial management and forest fire defense (Table 13), and land tenure (Figure 15) must be considered, as well as considerations on multi-risk areas.

Table 13. Instruments for territorial management and forest fire defense network.

List of instruments for territorial management and forest fire defense network for the AoI
Programa Nacional da Política de Ordenamento do Território (PNPOT) / National Programme of Regional Land-use Planning Policy
Plano de Ordenamento do Parque Natural Sintra-Cascais (POPNSC) / Regional Land-use Plan of Sintra-Cascais Natural Park
Plano Sectorial da Rede Natura 2000 (PSRN2000) / Nature 2000 Sectoral Plan
Programa da Orla Costeira Alcobaça-Cabo Espichel (POC-ACE) / Coastal Zone Programme of Alcobaça-Cabo Espichel
Plano de Gestão de Região Hidrográfica (PGRH) do Tejo e Ribeiras do Oeste / River basin Management Plano of Tejo e Ribeiras do Oeste
Plano Regional de Ordenamento do Território da Área Metropolitana de Lisboa (PROT-AML) / Regional Land-use Plan of the Metropolitan Area of Lisbon
Programa Regional de Ordenamento Florestal de Lisboa e Vale do Tejo (PROF-LVT) / Regional Programme of Forestry Management of Lisboa e Vale do Tejo
Plano Director Municipal de Cascais (PDM-Cascais) / Municipal Land-use Plan of Cascais
Plano Municipal de Defesa da Floresta Contra Incêndios (PMDFCI) de Cascais / Municipal Forest fire defense Plan
Plano Nacional de Defesa da Floresta Contra Incêndios / National Forest fire defense Plan
Plano Distrital de Defesa da Floresta Contra Incêndios / District Forest fire defense Plan
Planos Municipais de Defesa da Floresta Contra Incêndios dos concelhos vizinhos / Municipal Forest fire defense Plan of neighboring municipalities
Conselho Nacional de Reflorestação / National Council of Reforestation
Estratégia Nacional para as Florestas / National Strategy for Forests
Plano de Gestão Florestal / Forest Management Plan
Plano Municipal de Emergência e Protecção Civil / Municipal Plano of Emergency and Civil Protection

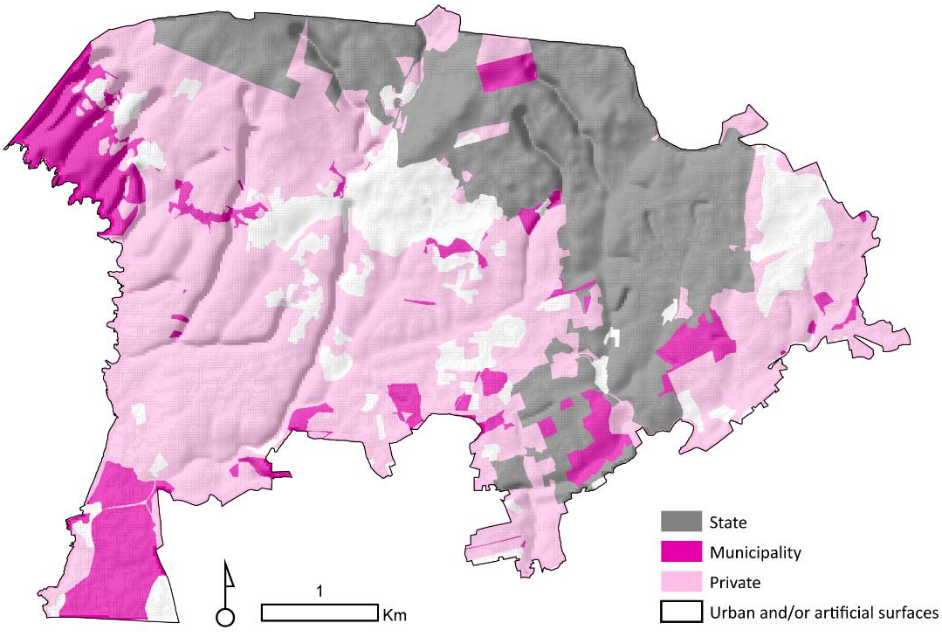


Figure 15. Map of land tenure for the AoI. Scale: 1:50.000.

- *Fuel management actions and Factors conditioning the actions.* A table like Table 4 will show different types of fuel management actions and factors that may condition the actions for the AoI, to be discussed in the focus group.

- *Cost of action per unit area.* It is necessary to quantify the cost of each action, in order to build a Matrix of budgeted solutions for Fuel Management for the AoI. A table like Table 5 will show a set of actions and the corresponding cost per hectare and total cost for the AoI. The information on this table will be discussed in the focus group.

- *Chronogram and frequency of fuel management actions*
  The chronogram, the actions to be performed and the entities that will perform them, must be discussed with the relevant stakeholders to be included in the OUTUT3 – Action Plan for Sustainable Management.

➢ **BUDGET OF FUEL MANAGEMENT**

Again, this budget is part of the final output and must be done by the AoI manager(s), with contributions from relevant stakeholders.

➢ **OUTPUT3: ACTION PLAN FOR SUSTAINABLE FUEL MANAGEMENT**

This final output is an operational document that envisages all the activities concerning fuel management in the AoI. As any action plan, it must be simple, concise, self-explanatory, and practical. This will allow the AoI manager(s) to consult and adjust it when necessary.

6. APPLICATION OF PREVAIL DSS-FM FOCUS GROUP GUIDELINES TO THE PORTUGUESE CASE STUDY (CASCAIS)

THE PREVAIL DSS-FM was tested by some stakeholders from the AoI. Supporting tables and information were prepared and sent in advance, to inform them about the discussion we wanted to carry on. This discussion had two main objectives: (1) to validate the roadmap suggested by PREVAIL team; (2) to discuss the steps that require stakeholder involvement, as described along the roadmap, and detailed in the following sections.

6.1. STAKEHOLDERS FOR CASCAIS CASE STUDY

- **SELECTION CRITERIA**

For the specific case of the Cascais AoI, we invited technicians from the municipality with responsibilities on fuel management, fire prevention and forest management. Since the Natural Park of Sintra-Cascais is within the territory of Cascais municipality, a representative of the Park was also considered. The Municipal Plan for Forest Fire Defense of Cascais needs to be approved by a commission (Municipal Commission for Forest Fire Defense - MCFFD), which includes landowners, electric company representatives, civil protection representatives, and other stakeholders involved in forest and fire prevention and management at several scales of intervention. At least one member of this commission was also invited for the focus group. The final number of participants was dependent on invited stakeholders' availability.

In sum, we had 5 participants in this focus group, namely: 2 technicians from the municipality, 1 representative of the Natural Park and 2 representatives of the commission. The focus group was planned to be conducted online with multimedia tools such as Zoom, Teams or Google meets.

The focus group was planned for participants to discuss the ranking of priorities of the elements at risk (e.g., vulnerability, value, and recovery time) and to contribute to assess landscape management and select the most suitable fuel management actions and treatment timings, having in consideration the specificities of the AoI.

- **STAKEHOLDERS SELECTED**

The focus group was carried out with the following 5 participants:

- 2 representatives (Rep1 and Rep2) of Cascais Ambiente. Cascais Ambiente is one delegation of the Municipality in charge of the conservation and enhancement of the environment, environmental education and knowledge in the AoI. The 2 representatives have different backgrounds and thus were able to contribute from different perspectives. One of the representatives is a forest engineer with expertise on ecology and management of forest stands from a landscape integrated perspective, and the other is a landscape architect with expertise on landscape aesthetics and landscape social interactions.
- 1 representative (Rep3) from the Municipal Forest Technical Bureau. This representative is responsible for defining the mandatory areas for fuel management in the AoI, as well as for the whole Municipal Plan for Forest Fire Defense Network. Thus, this

representative has a strong knowledge on legal obligations for the AoI and belongs to the MCFFD.

- 1 representative (Rep4) of the Firefighter Department of the AoI. This representative is the Firefighter Brigade Commander and has an operational perspective of the need to perform fuel management, and he also belongs to the MCFFD.
- 1 representative (Rep5) of the Portuguese Agency for Integrated Fire Management (AGIF). This Portuguese Agency was created by decree-law in 2018 and aims to be the entity that brings all other entities together and guides them towards the same national goal, which is to protect Portugal from severe rural fires. Therefore, this representative has a comprehensive and large-scale (national) perspective on the importance of having a structured roadmap for fuel management.

6.2. CASCAIS FOCUS GROUP DEVELOPMENT AND OUTCOMES

The focus group lasted for about 2h15. Focus group guiding material is available in Annex 1, in Portuguese, the language in which it was carried out.

The focus group started with a welcome speech and an overall presentation of the PREVAIL project (in particular, the DSS roadmap), objectives and expected outcomes of the session.

Afterwards, the Cascais case study was presented, by showing maps and information detailed in the previous sections of this deliverable. In this second part of the focus group, stakeholders were asked to specifically assess elements at risk (vulnerability, socioecological value, and recovery time), to generally discuss where to apply fuel management from a landscape integrated perspective, and to identify smart solutions that could be applied to or ongoing on the AoI.

➢ ASSESSMENT OF ELEMENTS AT RISK BY THE STAKEHOLDERS

The AoI was spatially shown in a map and because all selected stakeholders knew the AoI very well, it was not necessary to provide an individual map to each of them (this map would have been a high resolution LULC map for the AoI intended to visually show the spatial location of aerial/line features associated with the elements at risk).

An excel spreadsheet with Table 6, was sent to the chat group and each participant was asked to fill his/her own table, individually. At the same time, the moderator kept refreshing concepts and scales to be used in the classification. Minutes later, the moderator asked to each participant for the classification of a pair of elements at risk, to foster discussion. Finally, after all the steps being performed individually, the PREVAIL team gathered the information and presented it to be discussed among stakeholders (information shown in Table 14).

Table 14. Elements at risk at the AoI and its classification according to the stakeholders.

A	B	C	D	E	F	G
Elements at risk	**Vulnerability**	**Ecological value**	**Socio economic value**	**Socio ecological value**	**Recovery time**	**Final value**
Scale	**(0-1)**	**(1-4)**	**Tang. or intangible (€ or 1-4)**	**Keep blank (=D+E)**	**(1-4)**	**Keep blank (=B*E*F)**
Classification by Rep1 (Cascais Ambiente)						
Priority habitat 5210	1	4	4	8	4	32
Native species	1	4	4	8	4	32
Riparian vegetation	1	4	4	8	2	16
Mediterranean scrubland	1	3	2	5	1	5
Quercus pyrenaica stands	0,5	4	2	6	4	12
Natural grasslands	0	3	2	5	1	0
Agriculture mosaic	0	2	4	6	2	0
Temporary ponds	0	4	2	6	2	0
Dunesystem habitats	0,5	4	3	7	2	7
Nature tourism	1	1	4	5	2	10
Nature tourism infrastructures	1	2	3	5	2	10
Landscape	1	2	4	6	3	18
Classification by Rep2 (Cascais Ambiente)						
Native Quercus	0,9	4	4	8	3	21,6
Endangered native species	0,9	4	4	8	4	28,8
Built heritage (tanks, buildings, walls)	0,5	1	2	3	1	1,5
Agriculture and permanent pastures	0,7	2	€	2	2	2,8
Pisão Social Centre	1	1	4	5	3	15
Native plant genetic bank of Vale Cavalos	0,8	4	€	4	4	12,8
Classification by Rep3 (Municipal Forest Technical Bureau)						
Quercus stands	0,5	4	1	5	4	10
Pinus pinaster stands	0,8	3	1	4	3	9,6
Pinus halepensis stands	1	1	1	2	1	2
Riparian vegetation	0,3	4	1	5	4	6
Pastures	0,4	2	1	3	2	2,4
Shrublands	0,7	4	1	5	3	10,5
Housing sites	0,3	1	4	5	1	1,5
Business sites	0,6	1	4	5	1	3
Industrial sites	0,8	1	3	4	1	3,2
Classification by Rep4 (Commander of the Firefighters Brigade)						
Biodiversity	1	4	4	8	4	32
Touristic activity	0,2	2	2	4	1	0,8
Conservation forest	0,5	4	3	7	4	14
Pastures	1	2	2	4	2	8

Sintra-Cascais Natural Park	1	4	4	8	4	32
Built heritage	0,5	1	2	3	1	1,5
Pisão Social Centre	0,8	4	4	8	3	19,2
Barragem House	0,8	0	4	4	3	9,6
Native plant genetic bank of Vale Cavalos	0,2	1	4	4	4	3,2
Communication infrastructures	0,75	0	4	4	1	3
Energy infrastructures	0,75	0	4	4	1	3
IT infrastructures	0,75	0	4	4	1	3
Transportation infrastructures	0,5	0	4	4	1	2
Water points	0,5	4	4	8	3	12
Surveillance points	0,75	0	2	2	1	1,5
Classification by Rep5 (AGIF)						
Production forest	0,8	1	4	5	3	12
Agriculture	0,4	1	4	5	3	6
Buildings	1	1	4	5	3	15
Conservation forest	0,5	4	2	6	4	12
Pastures	1	2	1	3	1	3
Landscape	0,2	4	3	7	3	4,2
Biodiversity	0,5	4	4	8	3	12
Recreational activities	1	1	2	3	1	3
Tourism	1	2	2	4	1	4

As shown in Table 14, elements such as nature conservation and NATURA2000 sites were considered very important among stakeholders, and regardless of their distinct perspectives and expertise. Note that although infrastructures and settlements are absent in this exercise, all stakeholders considered them as important. Nevertheless, this type of elements was already included in the mandatory areas for fuel management.

➢ ASSESSMENT OF THE UTILITY AND SUGGESTIONS FOR IMPROVEMENT OF THE PREVAIL DSS-FM BY THE STAKEHOLDERS

No participant knew of other DSS for fuel management currently being used for supporting fuel management decisions.

All participants valued integrated management at the landscape scale, and according to them, the following points should be considered and further discussed:

- Perform an analysis of the historical large fire regime in the AoI (dominant fire patterns, wind, etc.) as a framing input,
- Perform a socioeconomic analysis (LULC dynamic, population density, WUI) to integrate the previous point,
- Identify priority habitats that could be badly damaged due to fuel management,
- Identify who will intervene in the territory; this is very important to ensure that the management is carried out by entities that will be able to maintain periodic interventions,

- Include the population from the settlements within the AoI on the discussions to achieve a better integration and acceptability of the actions.

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8. Annex 1 - Focus group guiding material. Portuguese session, March 9, 2020

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PREVENTION ACTION INCREASES
LARGE FIRE RESPONSE PREPAREDNESS

9 Março 2021 | 15h00 | Online

SESSÃO DE TRABALHO

Sistema de Apoio à Decisão (DSS) para a gestão de combustíveis à escala da paisagem

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PREVENTION ACTION INCREASES
LARGE FIRE RESPONSE PREPAREDNESS

Convidados:

- Cascais Ambiente;
- Cascais Ambiente;
- GTF Cascais;
- Bombeiros de Alcabideche
- AGIF

Equipa CEABN - ISA:

Arquiteta Catarina Sequeira;
Doutora Conceição Colaço;
Professor Francisco Rego;
Doutora Vanda Acácio.

Observadores PREVAIL:

Anna Barbati – Itália;
Davide Ascoli - Itália;
Marta Serra – Espanha;
Eduard Plana – Espanha.

PREVENTION ACTION INCREASES
LARGE FIRE RESPONSE PREPAREDNESS

PROGRAMA

Introdução (15 minutos)

- Boas Vindas;
- Enquadramento do projecto PREVAIL;
- Apresentação sumária do DSS;
- Objectivos e resultados esperados desta sessão de trabalho;

O Caso de estudo de Cascais (1h/1h15)

- Apresentação do caso de estudo de Cascais, passo a passo:

  * Valores em risco - Vulnerabilidade
    - Valor Socio-ecológico
    - Tempo de recuperação

  * Áreas a intervencionar – Gestão da paisagem;
  * Como e quando – Apresentação das "smart solutions"

Avaliação Final e encerramento – 15 min

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PREVENTION ACTION INCREASES
LARGE FIRE RESPONSE PREPAREDNESS

Projeto PREVAIL

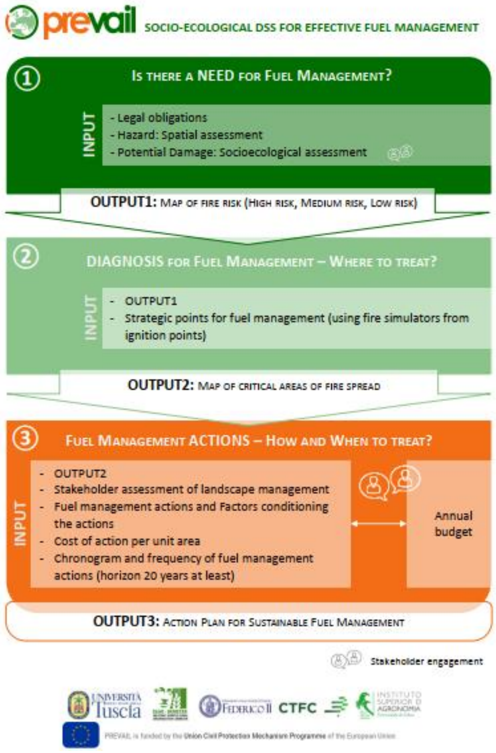
Os objetivos do PREVAIL são **identificar**, **testar** e promover **abordagens e ferramentas inovadoras** que permitam otimizar as ações **de prevenção** beneficiando a **preparação** e **capacidade de resposta** das autoridades e comunidades.

Principais objetivos:

- **Rever as medidas históricas e atuais de prevenção, preparação e supressão** para combater grandes incêndios e fornecer uma **avaliação económica** da eficácia da gestão atual de incêndios florestais;
- **Identificar padrões da paisagem** e dos determinantes do combustível florestal **no desenvolvimento e controle de grandes incêndios**;
- **Avaliar** as **melhores estratégias para integrar a prevenção** e a preparação para grandes incêndios, **partilhando e divulgando soluções "inteligentes"**, implementadas localmente em países parceiros;
- Desenvolver uma ferramenta (**Sistema de Apoio à Decisão**) para planear e otimizar soluções inteligentes para a gestão dos combustíveis à escala da bacia hidrográfica;
- **Sensibilizar os cidadãos, gestores florestais e bombeiros** e melhorar a cooperação e a partilha de boas práticas.

Sistema de Apoio à Decisão PREVAIL para Gestão de Combustíveis

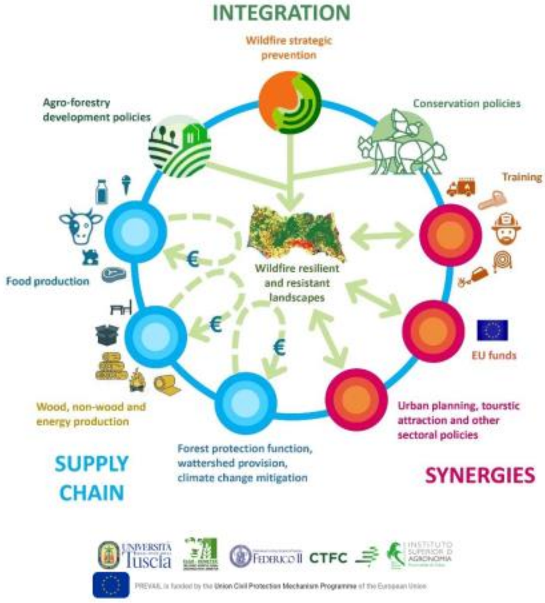
PREVENTION ACTION INCREASES
LARGE FIRE RESPONSE PREPAREDNESS



Abordagem PREVAIL às Soluções "Inteligentes" para a Gestão de Combustíveis

PREVENTION ACTION INCREASES
LARGE FIRE RESPONSE PREPAREDNESS

Medidas práticas e iniciativas implementadas de forma **sustentável**, potenciando a relação **custo-benefício**, otimizando as **sinergias e a cooperação** numa perspetiva multi-objetivo, capaz de capitalizar os **melhores conhecimentos existentes** e sendo permanentemente atualizada sob uma abordagem de **lições aprendidas**.



Iniciativas "inteligentes" para a gestão de combustíveis

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PREVENTION ACTION INCREASES LARGE FIRE RESPONSE PREPAREDNESS

INITIATIVE	COUNTRY	TERRITORIAL SCOPE
Training Centre of Toscana	Italy	Regional/Sub-regional
LIFE Granatha	Italy	Regional/Sub-regional
LIFE Elia-Art	International	International
Firefighting training centre of the Piemonte Region	Italy	Regional/Sub-regional
Grazing program for fire hazard abatement through the "Landa Carsica" business network	Italy	Regional/Sub-regional
Biomass production and fire hazard reduction in the Unione Comuni Pratomagno	Italy	Regional/Sub-regional
New Business Models for innovating the cork sector and contrasting cork oak woodland abandonment	Italy	National
LIFE Demogest	Spain	Regional/Sub-regional
Fire flocks' program	Spain	Regional/Sub-regional
LIFE Montserrat	Spain	Regional/Sub-regional
Assessment of biomass availability in the municipality of Calonge	Spain	Regional/Sub-regional
GEPRIF Project	Spain	National
Promobiomasse Project	International	International
LIFE Pinassa	Spain	Regional/Sub-regional
Boscos del Vallès (Valles Forest)	Spain	Regional/Sub-regional
Alberapastur Project	International	International
Quality-Suber	Spain	Regional/Sub-regional
Sustainable Forest Management Orientations for Catalonia (ORGEST)	Spain	Regional/Sub-regional
Action areas enlargement of large fires prevention plan of Matadepera municipality	Spain	Regional/Sub-regional
Priority Protection Perimeters for Forest Areas (PPPF)	Spain	Regional/Sub-regional
Cabra serrana nos Baldios da Malcata	Portugal	Regional/Sub-regional
Shepherds' School	Portugal	National
Open2preserve Project	International	International
SILVPAST Operational Group	Portugal	National
Forest Management - ACHLI	Portugal	National
Reserva Faia Brava	Portugal	National
Rebanhos da Serra do Açor-Rabadão	Portugal	Regional/Sub-regional
Landscape fire Project	International	International
Resilient forest Project	International	International
LIFETEC Project	International	International
REFOREST Project	International	International
Integrated Fire Prevention Plan - PreFeu initiative Upper Val Susa	Italy	Regional/Sub-regional

Perigosidade estrutural (2013) e iniciativas que implementam soluções "inteligentes" para a gestão de combustíveis

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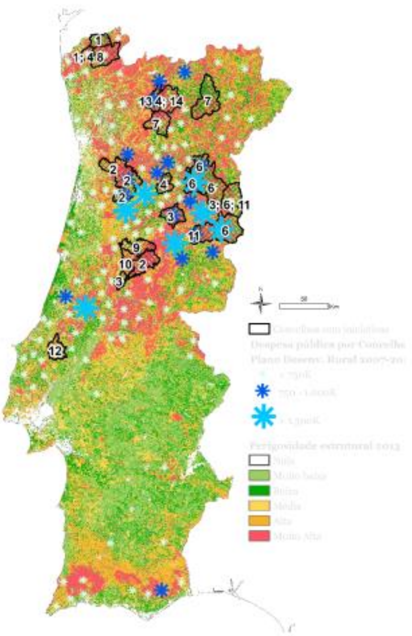
PREVENTION ACTION INCREASES LARGE FIRE RESPONSE PREPAREDNESS



Actividade económica principal		
Conservação/ Mosaicos	1:	ACHLI – Assoc. Conserv. do Habitat do Lobo Ibérico
	2:	Montis
	3:	REN – Rede Eléctrica Nacional
Resinagem	4:	RaízesIn – Raízes Independentes
Pastoreio	5:	INOVCLUSTER - Escola de Pastores
	6:	ATNatureza - Reserva da Faia Brava
	7:	Projecto I&D Open2Preserve
	8:	Quinta Lógica
	9:	Rebanho Comunitário de Casal Novo e Cepos
	10:	Rebanhos da Serra do Açor e Rabadão
	11:	Grupo Operacional SILVPAST
	12:	Cooperativa Terra Chã
	13:	Terra Maronesa
Gestão florestal	14:	AguiarFloresta

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Objectivos e resultados esperados desta sessão de trabalho;

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PREVENTION ACTION INCREASES
LARGE FIRE RESPONSE PREPAREDNESS

- **Validação do DSS face à experiência dos convidados;**
- **Propostas de melhoria;**
- **Construção com os dados reais do concelho de Cascais.**

* Valores em risco – Vulnerabilidade

- Valor Socio-ecológico
- Tempo de recuperação

* Áreas a intervencionar – Gestão da paisagem;

* Como e quando – Apresentação das “smart solutions”

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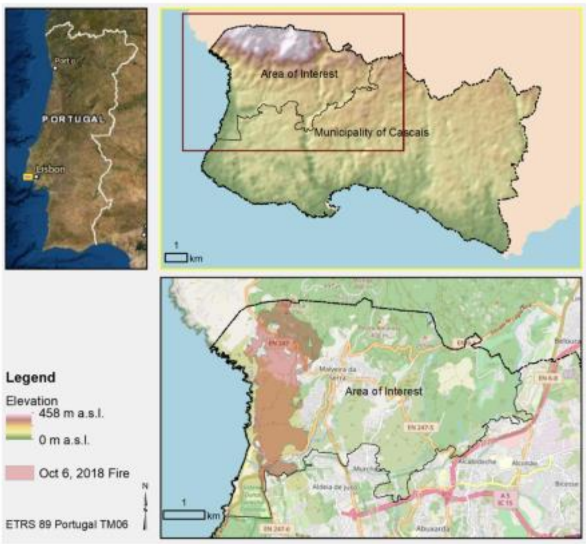
prevail

PREVENTION ACTION INCREASES
LARGE FIRE RESPONSE PREPAREDNESS

O caso de estudo de Cascais



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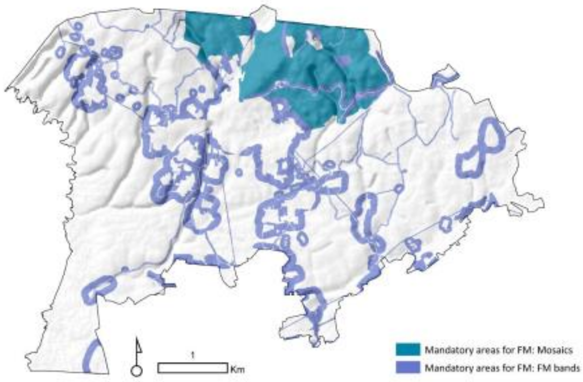
1 **HÁ NECESSIDADE DE FAZER GESTÃO DE COMBUSTÍVEL?**

PREVENTION ACTION INCREASES
LARGE FIRE RESPONSE PREPAREDNESS

INPUT1: OBRIGAÇÕES LEGAIS DE GESTÃO DE COMBUSTÍVEL



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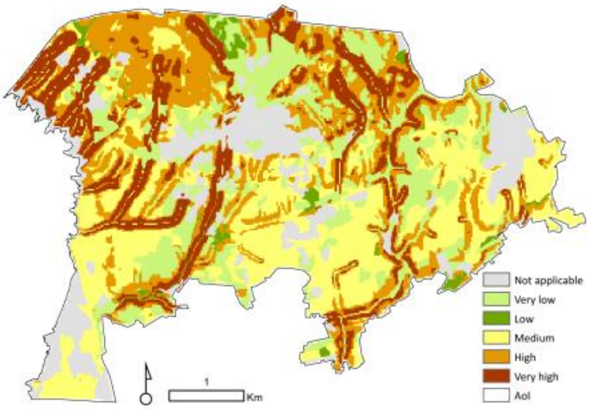
1 **HÁ NECESSIDADE DE FAZER GESTÃO DE COMBUSTÍVEL?**

PREVENTION ACTION INCREASES
LARGE FIRE RESPONSE PREPAREDNESS

INPUT2: RISCO – ANÁLISE ESPACIAL



Mapa de Risco – Análise espacial (escala 1:50.000)

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1 HÁ NECESSIDADE DE FAZER GESTÃO DE COMBUSTÍVEL?

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INPUT3: DANO POTENCIAL – ANÁLISE SOCIO-ECOLÓGICA

- Vulnerabilidade ao fogo: % de dano em caso de ocorrência de incêndio (0-1 para cada valor em risco)
- Valor socio-ecológico: valor ecológico ou socioeconómico do valor em risco (1-4 para cada valor em risco. 1: baixo valor, 4: muito alto valor)

Value at risk		Vulnerability	Value
Forest	Agroforestry	0,50	150 €/ha
	Other oaks	0,60	1087 €/ha
	Eucalyptus	0,80	1125 €/ha
	Invasive species	1,00	0 €/ha
	Other hardwoods	0,50	1507 €/ha
	Pinus pinaster	1,00	1480 €/ha
	Pinus pinea	1,00	1553 €/ha
	Other softwoods	1,00	1400 €/ha
	Shrubland	0,40	52,5 €/ha

Valores económicos atribuídos no PMDFCI Cascais

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VALORES EM RISCO NA ÁREA DE ESTUDO

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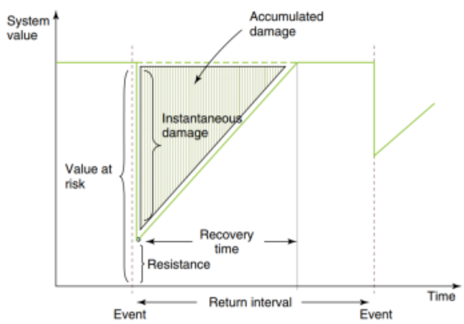
VALOR EM RISCO	ORDEM IMPORTÂNCIA (1-4)	VULNERABILIDADE (0-1)	VALOR ECOLÓGICO (1-4)	VALOR SOCIO-ECONÓMICO Tangivel ou intangivel (euros ou de 1 a 4)

VALOR SOCIOECOLÓGICO NÃO PREENCHER	PERIODO RECUPERAÇÃO (1-4)	VALOR FINAL NÃO PREENCHER
0		0
0		0
0		0
0		0



Classificação final dos valores em risco na área de estudo de acordo com as partes interessadas

(PARA COMPLETAR EM EXCEL)

	1º	2º	3º	4º		5º	6º
PASSOS	Listar os valores em risco	Ordenar por importância	Classificar quanto à vulnerabilidade	Classificar o seu valor eco-socioeconomic (classificar em separado e depois somar os 2 valores)		Classificar o periodo de recup.	Calcular valor final
	VALOR EM RISCO	ORDEM IMPORTÂNCIA	VULNERAB. (% DANO)	VALOR ECOLÓGICO	VALOR SOCIO-ECONOMICO	PERIODO RECUP.	VALOR FINAL
ESCALA	N/A	(1-4)	(0-1)	(1-4)	Tangivel ou intangivel	(1-4)	Multiplicar as anteriores

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Valores em risco na área de estudo (exemplo)

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Value at risk		Vulnerability	Eco-socioeconomic value	Recovery time
Communication	- Very high voltage energy transmission network - High voltage energy transmission network - Energy transmission network	Mandatory for Portugal. It is already included in the forest fire defense network		
Energy	Gas transmission network			
Technology and information	Telecommunication network			
Transportation	- Road network - Railway network			
Water	Firefighting water points			
Fire lookout points				
Touristic areas and historical heritage	Sintra-Cascais Natural Park (SCNP)	The SCNP is already considered above, within the protected area		
Agriculture and food	Agriculture	0,5	3	2
	Pastures	0,5	2	2
Areas with conservation status	SCNP Protected area – Areas Full Protection	1	4	4
	SCNP Protected area – Areas Type I	0,8	4	3
	SCNP Protected area – Areas Type II	0,7	4	3
	SCNP Protected area – Complementary Areas	0,6	4	3
	Site of Community Importance - Natura 2000. PTCON0008	1	4	3
Forest	Agroforestry	0,50	3	3
	Other oaks	0,60	3	3
	Eucalyptus	0,80	3	2
	Invasive species	1,00	1	1
	Other hardwoods	0,50	3	3
	Pinus pinaster	1,00	3	3
	Pinus pinea	1,00	3	3
	Other softwoods	1,00	3	3
	Shrubland	0,40	2	1

1 **HÁ NECESSIDADE DE FAZER GESTÃO DE COMBUSTÍVEL?**

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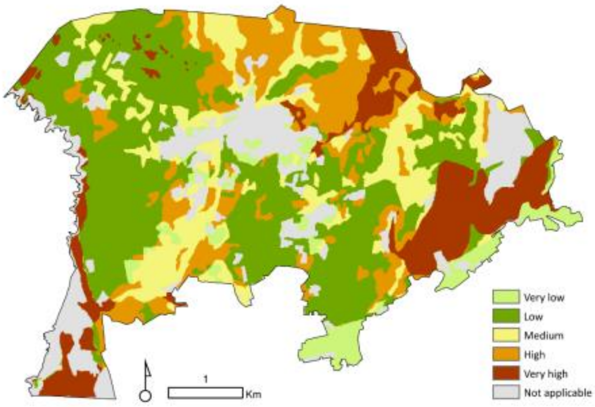
INPUT3: DANO POTENCIAL – ANÁLISE SOCIO-ECOLÓGICA



Mapa de Dano potencial – Análise socio-ecológica (escala 1:50.000)

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MATRIZ ESPACIAL COM AS CLASSES "HIGH RISK", "MEDIUM RISK", E "LOW RISK"

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		RISCO: Análise espacial					
		0: Null	**1: Very low**	**2: Low**	**3: Medium**	**4: High**	**5: Very high**
DANO POTENCIAL: Análise socioecológica	**0: Null**	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
	1: Very low	Low risk	Low risk	Low risk	Low risk	Medium risk	Medium risk
	2: Low	Low risk	Low risk	Medium risk	Medium risk	Medium risk	Medium risk
	3: Medium	Low risk	Low risk	Medium risk	Medium risk	High risk	High risk
	4: High	Low risk	Low risk	Medium risk	High risk	High risk	High risk
	5: Very high	Low risk	Medium risk	Medium risk	High risk	High risk	High risk

Medium risk is Cost-dependent

Número de classes d

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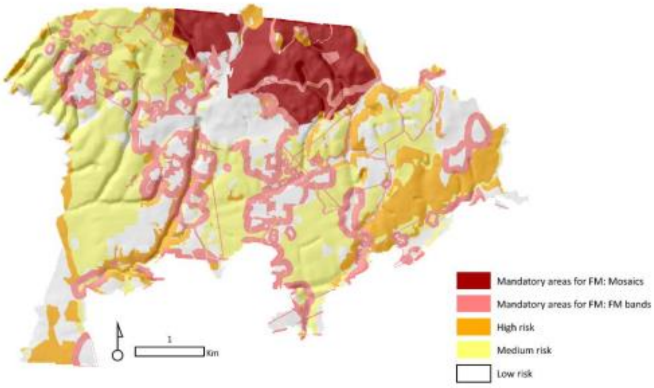
1 HÁ NECESSIDADE DE FAZER GESTÃO DE COMBUSTÍVEL?

OUTPUT1: MAPA DE RISCO DE INCÊNDIO



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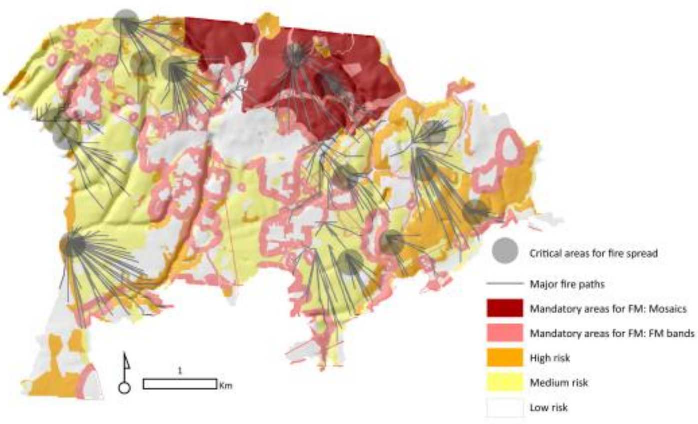
2 DIAGNÓSTICO PARA GESTÃO DE COMBUSTÍVEL: ONDE TRATAR?

OUTPUT2: MAPA DE ÁREAS CRITICAS DE PROPAGAÇÃO DO FOGO



Mapa de áreas criticas de propagação do fogo (escala 1:50.000)

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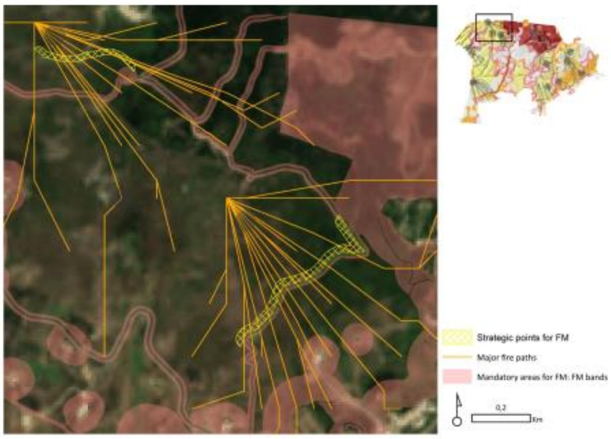
OUTPUT2A: PONTOS ESTRATÉGICOS DE GESTÃO DE COMBUSTÍVEL



Mapa de pontos estratégicos de gestão (escala 1:10.000). Exemplo

http://ortos.dgterritorio.pt/wms/IPSentinel2PT?service=WMS&REQUEST=Getcapabilities&VERSION=1.3.0

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2 DIAGNÓSTICO PARA GESTÃO DE COMBUSTÍVEL: ONDE TRATAR?

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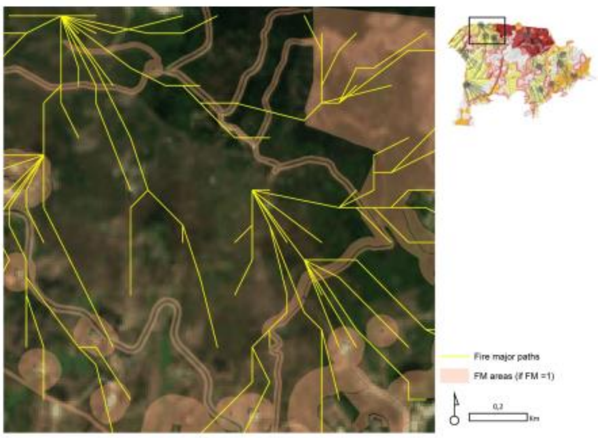
OUTPUT2A: PONTOS ESTRATÉGICOS DE GESTÃO DE COMBUSTÍVEL



Se as faixas de gestão de combustivel tivessem modelo de combustivel 1

(escala 1:10.000)

http://ortos.dgterritorio.pt/wms/IPSentinel2PT?service=WMS&REQUEST=Getcapabilities&VERSION=1.3.0

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2 DIAGNÓSTICO PARA GESTÃO DE COMBUSTÍVEL: ONDE TRATAR?

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QUE OUTROS PONTOS DEVEM SER CONSIDERADOS PARA INTERVIR NA PAISAGEM?

COMO OS DEFINIR E LOCALIZAR NO ESPAÇO ?

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3 AÇÕES DE GESTÃO DE COMBUSTÍVEIS: COMO E QUANDO TRATAR?

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INSTRUMENTOS DE GESTÃO TERRITORIAL E DFCI PARA A ÁREA DE ESTUDO

Programa Nacional da Política de Ordenamento do Território (PNPOT)
Plano de Ordenamento do Parque Natural Sintra-Cascais (POPNSC)
Plano Sectorial da Rede Natura 2000 (PSRN2000)
Programa da Orla Costeira Alcobaça-Cabo Espichel (POC-ACE)
Plano de Gestão de Região Hidrográfica (PGRH) do Tejo e Ribeiras do Oeste
Plano Regional de Ordenamento do Território da Área Metropolitana de Lisboa (PROT-AML)
Programa Regional de Ordenamento Florestal de Lisboa e Vale do Tejo (PROF-LVT)
Plano Director Municipal de Cascais (PDM-Cascais)
Plano Municipal de Defesa da Floresta Contra Incêndios (PMDFCI) de Cascais
Plano Nacional de Defesa da Floresta Contra Incêndios
Plano Distrital de Defesa da Floresta Contra Incêndios
Planos Municipais de Defesa da Floresta Contra Incêndios dos concelhos vizinhos
Conselho Nacional de Reflorestação
Estratégia Nacional para as Florestas
Plano Regional de Ordenamento do Território
Plano Especial de Ordenamento do Território
Plano de Gestão Florestal
Plano Municipal de Emergência e Protecção Civil

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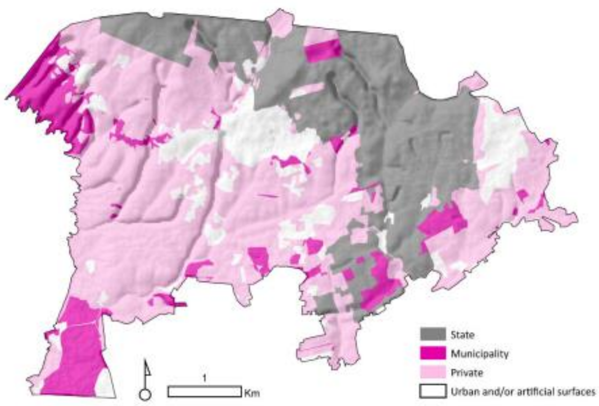
3 AÇÕES DE GESTÃO DE COMBUSTÍVEIS: COMO E QUANDO TRATAR?

PROPRIEDADE



Mapa de regime de propriedade da área de estudo (escala: 1:50.000)

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3 AÇÕES DE GESTÃO DE COMBUSTÍVEIS: COMO E QUANDO TRATAR?

INPUT: FATORES CONDICIONANTES E SUAS CARACTERÍSTICAS PARA A ÁREA DE ESTUDO

					FACTORES CONDICIONANTES DAS AÇÕES				
					Fumo	Declive	Meteo-rologia	Uso do solo	Etc.
Ações de gestão de combustível	Business as usual	**Maquinaria**							
		Maquinaria pesada							
		Fogo controlado							
	Gestão integrada da paisagem para prevenção de incêndios (Soluções Inteligentes)	Gestão agroflorestal	Pastorícia	Ovelhas					
				Cabras					
				Vacas					
			Conservação	Animais bravios					
			Produtos florestais lenhosos						
			Produtos florestais não-lenhosos	Extração de resina					
				Cogumelos					

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3 AÇÕES DE GESTÃO DE COMBUSTÍVEIS: COMO E QUANDO TRATAR?

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INPUT: POSSÍVEIS AÇÕES DE GESTÃO DE COMBUSTÍVEIS SELECIONADAS PARA A ÁREA DE ESTUDO

		EUR por hectare	Hectares necessários	Custo
Ações seleccionadas	Maquinaria			
	Maquinaria pesada			
	Fogo controlado			
	Etc. (outras ações de gestão de combustível seleccionadas nos passos anteriores)			
Combinação de técnicas				
	Total			

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3 AÇÕES DE GESTÃO DE COMBUSTÍVEIS: COMO E QUANDO TRATAR?

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INPUT: CRONOGRAMA POR PARCELA PARA CADA AÇÃO

Área de estudo	Técnica a ser usada	1ª Intervenção (data)	2ª Interv. (data)	3ª Interv. (data)	4ª Interv. (data)	5ª Interv. (data)	Etc.
Parcela1							
Parcela2							
Parcela3							
Etc.							

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3 AÇÕES DE GESTÃO DE COMBUSTÍVEIS: COMO E QUANDO TRATAR?

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OUTPUT3: PLANO DE AÇÃO PARA A GESTÃO SUSTENTÁVEL DE COMBUSTÍVEIS

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AVALIAÇÃO

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CONSIDERA QUE ESTE TIPO DE DSS É ÚTIL E FAZ SENTIDO?

COMO MELHORÁ-LO?

CONHECE OUTROS DSS QUE ESTEJAM EM FUNCIONAMENTO?

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9 Março 2021 | 15h00 | Online

SESSÃO DE TRABALHO

Sistema de Apoio à Decisão para a gestão de combustíveis à escala da paisagem

MUITO OBRIGADO PELA VOSSA PARTICIPAÇÃO E CONTRIBUTOS!

https://www.prevailforestfires.eu/

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