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PREVENTION ACTION INCREASES
LARGE FIRE RESPONSE PREPAREDNESS

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WP3. LARGE FIRES CASE STUDIES ANALYSIS

Deliverable 3.1. – Data Collection

Lead beneficiary:
Hellenic Agricultural Organization DEMETER

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Lead partner of task: Ellinikos Georgikos Organismos - DIMITRA

DELIVERABLE SUMMARY

Deliverable 3.1 describes the Data Collection procedure regarding Large Fires in the EU. This procedure has two distinct parts, resulting in two different datasets. More specifically, two types of data will be collected and used:

1. Data from fire statistics databases for identification of influential variables and establishment of relationships with burned area size.
2. Data from selected large fires for in-depth study, especially regarding the conditions under which they have evolved and were finally stopped.

The first dataset will include fires over 500 ha from the national fire statistics databases. A format for the development of the database is described in this deliverable.

In the second part, the work will not be based only on fire statistics. A set of case studies of large fires will be developed by the Project Partners. Each fire will be documented as precisely as possible, including, in addition to the official statistics, information about landscape patterns, fuels, and weather (e.g., Fire weather index – FWI -, drought, synoptic meteorological conditions). This information will be coupled with other variables including topography, resources, special fire-fighting difficulties and shortcomings, to examine where and under what conditions large fires are triggered and develop.

Fuels are the focus of this part. Detailed analysis will focus on characterization of the final perimeter of each fire, examining the location where the fires were stopped (topographic features (ridges, water bodies, etc.), urban areas (cities, towns, villages), type of fuel and fuel continuity (areas of fuel treatment, rocky areas (no fuel), agricultural areas, grasslands, scrublands, high forests, etc.), as well as the time of the day and the meteorological conditions. This will be done through a combination of official burned area maps, pre- and post-fire satellite images and, where necessary and possible, on-site visits.

The overall aim of the selected large fires analysis will be to identify the weather conditions and the fire prone landscape patterns that, in combination, steeply increase the probability that a starting fire will develop into a large fire. Furthermore, through the statistical analysis of these large fire case studies, it will be tried to identify the relative contribution of landscape pattern determinants on large fire development. This basic knowledge, together with the identification of fire-prone landscape patterns (an almost static property for a given fire season), will be used to propose refinements in current approaches in day-to-day (dynamic) production of fire risk maps, utilizing the combination of weather prevision and landscape characteristics.

Table of Contents

Introduction

Large fires are considered as the product of extreme weather events, such as heat waves with the intrusion of hot and dry Saharan air masses from the south to the Mediterranean basin, and high fuel loads, potentially burning as simultaneous fire events in and around peri-urban areas (often termed wildland-urban interface (WUI) areas). However, the interaction of weather, fuels and fuel management measures, roads, other fire spread obstacles, houses, and other infrastructures, and firefighting in affecting how wildfires become large and how they are stopped, is quite complex and has not been investigated in depth. WP3 seeks to improve our understanding about how wildfires become large and devastating in order to guide mitigation efforts that aim to lessen the chance of fires becoming large and/or reduce their impact. Therefore, the overall objective of this WP is to analyze how biophysical, social, and economic interactions between external drivers and forest / fuel management alternatives can deliver the tools for an integrative landscape scale approach, to mitigate the risk of wildfires developing into large fires. Detailed aims are to:

- identify patterns of large fire events (synoptic weather, fuel, and landscape / peri-urban district);
- establish and adopt methods for the analysis of the interaction between landscape, weather, and human activity in the development of extremely large fire;
- evaluate which landscape scale fuel management approach is the best strategy to mitigate risk;
- test (and evaluate the impact of) innovative fuel management techniques (e.g. prescribed burning) and spatial patterns on landscape scale;
- use innovative ways to visualize and discuss fuel management alternatives with stakeholders and communicate the findings.

As a first step towards meeting these objectives it is necessary to analyze data on large fires in order to improve our understanding about them. The type of data that will be collected, the procedure and the format, including the database and the associated parameters form the content of deliverable 3.1. More specifically, two types of data will be collected and used:

- Data from fire statistics databases for identification of influential variables and establishment of relationships with burned area size.
- Data from selected large fires for in-depth study, especially regarding the conditions under which they have evolved and were finally stopped.

Database 1: Data from fire statistics databases

Some form of fires statistics data are collected in all Mediterranean EU countries. However, in spite of efforts to homogenize databases and make them easily accessible, this objective has not been achieved. The data are not readily accessible because they are not collected at country level so the collection effort needs to be done at regional/autonomy level. Furthermore, the data collected and the form in which they are available varies.

Part of the work of the cooperating research groups in PREVAIL is to work on identifying available databases in the partner Mediterranean EU countries (Portugal, Spain, Italy and Greece) and composing a large database, specifically for large fires, hereafter called Database 1, for statistical analysis.

As the investigation focuses on large fires we set a minimum of 500 ha for a fire to be considered as large. As a rule, such fires have escaped initial attack and have spread rapidly for some time before a change in weather and/or fuels, and/or an increase in the available firefighting resources, results in their control. The 500 ha lower threshold, allows for later selecting a sub sample (e.g. fires over 1000 ha) and testing if any relationships identified in the complete database still hold.

Variables in Database 1

The variables that are desirable to be included in Database 1 are presented in Table 1. It is understood that all the variables are not going to be available in all countries. After trying to develop as complete a database as possible, analyses will probably have to be carried out on subsets, depending on the missing variables.

Table 1. Variables that should be included in Large Fires Database 1.

Short name	Description	Justification
NUM	Unique number of a particular fire in the database	Identifies a fire uniquely, does not change with shorting
COUNTRY	Country in which the fire occurred	Allows for shorting and examination of differences. The strength of fire suppression organization may be different between countries. Vegetation and climate may also be different.
MANUNIT	Management Unit	Makes it easier to locate a particular fire. May reveal spatial differences
LATITUDE	Latitude (WGS 84)	In the Mediterranean, it is likely that fires are more intense in the south. There may be differences in vegetation. In addition, timing of fires in the year may be different.
LONGITUDE	Longitude (WGS 84)	Probably less important. However, the proximity to the west coast may be an influential factor.
DATE	Date of fire start	It identifies the period in the year. May help assess the peak of the fire season in each country and in the Mediterranean.
TIME	Time of fire start	It is related with the burning conditions, the available time for intense fire behavior and the available time for firefighting under daylight.
ELEVATION	Elevation A.S.L. where the fire started (m)	Elevation influences the fire environment (vegetation, fuels and their condition, weather). Higher elevation is usually associated with rough topography and fewer roads.

TEMP	Air temperature (^{O} C)	Air temperature influences the ease of ignition of fuels and the likelihood of spot fires
RH	Air relative humidity (%)	Relative humidity influences the moisture content (MC, %) of dead fuels. Lower MC makes their ignition faster.
WIND	Wind speed (km h^{-1})	Wind influences the rate of spread of the fire
SLOPE	Slope (%) of the area where the fire started	The steeper the slope the higher the rate of spread and the more difficult to fight the fire
AIRDISTANCE	Distance of closest air resources base (km)	It is likely that the closest the air resources are located to the fire area the more effective the air support (timely, quick arrival of reinforcements)
WATERDISTANCE	Distance from water (sea or lake or reservoir) (km)	This distance may affect the effectiveness of amphibian waterbombers and helicopters that can pick-up water from the sea or a lake
FIRSTINT	Time of first intervention of firefighting resources (min)	The longer this time, the fire has a better opportunity to grow and become large.
BURNEDFOREST	Burned forest area (ha)	Burned area of forests, large and small shrubs and forest grasslands. Fire in these vegetation types are generally more difficult to fight
BURNEDAREA	Total burned area (ha)	Burned area of all types of vegetation including agricultural land (ha).
VEGETATION[1]	Weighted fire hazard estimate for the vegetation types that burned (rating 1-5)	Various types of vegetation have different fire intensity and ROS potential, as well as "difficulty of control". Weighing is based on the fire hazard rating for each type and its contribution to the total burned area (ha)
PAR_FIRES[2]	Number of small and large fires that were burning or started on that day (not including this fire)	This is an indication of the firefighting load that existed and may be related to the availability of inadequate resources
PAR_LFIRES[2]	Number of large fires (>500 ha) that were burning or started on that day (not including this fire)	This is an indication of the difficulties the firefighting organization had to face. It is likely that there were inadequate resources and the fire weather conditions were very adverse.
FIREFIGHTERS	Number of firefighters including official volunteer firefighters	They carry out ground firefighting

OTHER_CONTR	Other contributing personnel not specialized in firefighting (Army personnel, Local authorities, etc.)	They contribute to the firefighting capacity
FIRETRUCKS	Number of firetrucks (all types)	They contribute to the firefighting capacity on the ground
HEAVYMACHINES	Number of heavy machinery such as dozers	They contribute to the firefighting capacity on the ground
AIRPLANES	Number of airplanes (all types)	They contribute to the firefighting capacity from the air
AMPHIBIAN	Number of amphibian airplanes (subset of AIRPLANES)	They contribute to the firefighting capacity from the air
HELICOPTERS	Number of Helicopters	They contribute to the firefighting capacity from the air

[1]Regarding VEGETATION, the approach proposed is to give a rating of the "average weighted" flammability (VF) of the vegetation types that burned. This can be based on the rankings produced by Xanthopoulos et al. 2012, weighting by the burned area in the various vegetation types that a particular fire run through.

$$VF = \frac{\beta_1 * \alpha_1 + \beta_2 * \alpha_2 + \cdots + \beta_v * \alpha_v}{\alpha_1 + \alpha_2 + \cdots + \alpha_v}$$

Where: β_v = Flammability index of vegetation type v

α_v = Number of ha burned of vegetation type v

Xanthopoulos, G., P. Fernandes, C. Calfapietra. 2012. Fire hazard and flammability of European forest types pp. 79-92. In Moreira, F., M. Arianoutsou, P. Corona, and J. De las Heras (Eds.). Post-Fire Management and Restoration of Southern European Forests. Springer, Heidelberg. 329 p.

[2]The absolute number here can be of importance when referring to one country. Initially the number is needed. In the analysis phase it will be necessary to normalize these variables in some way. For example they may be divided by the size of the country or region, or by the average number of fires.

Database 2: Detailed data on specific wildfires

Although currently being viewed as single and rare events, large wildfires are occurring following certain patterns that can be analysed. To achieve this, a set of case studies provided by the Project Partners and taking advantage of similar assessments done in previous projects on recent large fires from Europe will be collected based on established templates. Existing databases (e.g., http://emergency.copernicus.eu/mapping/list-of-activations-rapid) and information derived from the project partners will help to identify, select, and build the case studies (minimum set of five case studies per country). Each fire will be documented as precisely as possible, including, in addition to the official statistics, information about landscape patterns, fuels, and weather (e.g., Fire weather index – FWI -, drought, synoptic meteorological conditions). This information will be coupled with other variables including social drivers, topography, resources, special fire-fighting difficulties (such as simultaneity of fire ignitions) and shortcomings, to examine where and under what conditions large fires are triggered and develop.

The creation of the database will take into consideration recent research findings on large fires. For example, based on fire statistics, San Miguel Ayanz et al. (2013), have shown that large fires are driven by critical weather conditions that lead to a concentration of numerous large fires in time and space (fire clusters) and that they occur independently of the available fire-fighting resources. Similarly, Dimitrakopoulos et al. (2011) found a correlation between large fires and strong wind but also concluded that any fire may become large under certain conditions.

In this task, the work will not be based only on fire statistics. As fuels are the focus of this WP, a detailed analysis will focus on characterization of the final perimeter of each fire, examining the location where the fires were stopped (topographic features (ridges, water bodies, etc.), urban areas (cities, towns, villages), type of fuel and fuel continuity (areas of fuel treatment, rocky areas (no fuel), agricultural areas, grasslands, scrublands, high forests, etc.), as well as the time of the day and the meteorological conditions. This will be done through a combination of official burned area maps, pre- and post-fire satellite images and, where necessary and possible, on-site visits.

The overall aim of the selected large fires analysis will be to identify the weather conditions and the fire prone landscape patterns that, in combination, steeply increase the probability that a starting fire will develop into a large fire. Furthermore, through the statistical analysis of these large fire case studies, it will be tried to identify the relative contribution of landscape pattern determinants on large fire development. This basic knowledge, together with the identification of fire-prone landscape patterns (an almost static property for a given fire season), will be used to propose refinements in current approaches in day-to-day (dynamic) production of fire risk maps, utilizing the combination of weather prevision and landscape characteristics.

A separate description (narrative) of varying length will be prepared for each of the selected fires. The data for each fire will include values for all the variables mentioned in table 1 plus additional data as described below:

Factors related to firefighting

Duration of firefighting until control of active fire spread

This is a metric of the <u>hours</u> during which the fire was spreading actively, i.e. until it was brought under control (no more active perimeter spread). In large fires firefighting usually continues for many days after control (e.g. for mop-up, control of small re-starts, etc.) but the FF_DURATION does not take those days into consideration. The time within which nearly all of the area (ha) burned, is an indication of the dynamics of the fire and the difficulty the firefighting forces had to control it.

Fire perimeter (as regards where the firefighters are more likely to control a fire)

External fire perimeter where the fire ended in the form “length by vegetation/land use type”. The vegetation/land use type is expected to affect the difficulty of stopping a fire. The fire perimeter will be traced in a GIS environment over a satellite or orthophoto image, identifying the various vegetation/land use types, according to proposed table 2 below.

Table 2. Vegetation/land use types along the final fire perimeter

	Vegetation/land use type
1	Sea
2	Lake/pod
3	River
4	Unpaved narrow Road
5	Paved road (two lane)
6	Wide road (more than two lanes)
7	Railway lines
8	Bare ground
9	Firebreak (linear)
10	Fuelbreak or managed fuels (incl. prescribed burned)
11	Green belt (football field, golf course, etc.)
12	Tree orchard (other than olive)
13	Olive grove
14	Vineyard
15	Annual agricultural cultivation (wheat etc.)
16	Greenhouse
17	Grassland
18	Phrygana/Scrub
19	Low shrubs (<70 cm)
20	Medium shrubs (<150 cm)
21	Tall shrubs (150 cm< h < 400 cm)
22	Pine forest
23	Tall conifer forest (other than pine)
24	Oak forest
25	Eucalypt forest
26	Other broadleaved tall forest
27	WUI area (interspersed)
28	Settlement/Village
29	Town/City
30	Industrial area
31	Quarry
32	Recently burned area (3 years or less)

Fire perimeter of unburned islands within the burned area

Fire perimeter of unburned islands within the burned area will be traced using the classes of Table 2 (similar to the external fire perimeter). The minimum size of islands to be considered is 5 ha. As the fire was stopped along this perimeter, it is likely that some favorable conditions existed for the firefighters (e.g. fuel treated area, sparse vegetation, WUI area, etc.). Even if the overall fire finally engulfed this unburned "island" and progressed further, the information about the influence of the particular vegetation/land use type along this perimeter is important. Obviously, it is necessary to digitize the perimeter of the unburned islands (as a polygon shapefile) in order to obtain these metrics. The output will be:

- A linear metric (length of the total perimeter of these unburned islands (in m))
- An area metric (total area of unburned islands (in ha))
- A table of length of fire perimeter by vegetation/land use type, of where the fire was stopped.

Area coverage of fuels

Fuels are one of the main determinants of fire behavior. Naturally bare areas, areas with managed forest fuels and agricultural cultivations are expected to mitigate fire behavior. Analyses will explore the extent to which these types are present in the large fires that will be included in the sample. Additionally, it will be examined how coverage of vegetation/land use type is related to "length by vegetation/land use type". Table 3 below, lists the proposed vegetation/land use coverage types. It is the same as Table 3 but the clearly linear features have been shaded and should not be used. The area coverage according to table 3 does not have to be extremely detailed. It can be based on an existing classification (e.g. forest maps, CORINE) with manually introduced refinements (subdivisions of types).

Table 3. Vegetation/land use types regarding area coverage

	Vegetation/land use type
1	Sea
2	Lake/pod
3	River
4	Unpaved narrow Road
5	Paved road (two lane)
6	Wide road (more than two lanes)
7	Railway lines
8	Bare ground
9	Firebreak (linear)
10	Fuelbreak or managed fuels (incl. prescribed burned)
11	Green belt (football field, golf course, etc.)
12	Tree orchard (other than olive)
13	Olive grove
14	Vineyard
15	Annual agricultural cultivation (wheat etc.)
16	Greenhouse
17	Grassland
18	Phrygana/Scrub
19	Low shrubs (<70 cm)

20	Medium shrubs (<150 cm)
21	Tall shrubs (150 cm< h < 400 cm)
22	Pine forest
23	Tall conifer forest (other than pine)
24	Oak forest
25	Eucalypt forest
26	Other broadleaved tall forest
27	WUI area (interspersed)
28	Settlement/Village
29	Town/City
30	Industrial area
31	Quarry
32	Recently burned area (3 years or less)

Landscape characterization

Topography

Two metrics will be used to characterize topography.

- Minimum & maximum elevation found within the burned area
- Burned area segments (ha) in five (5) slope classes as follows:

  Class 1: 0-10%,
  Class 2: 10-25%,
  Class 3: 25-50%,
  Class 4: 50-80%,
  Class 5: over 80%

The second metric will require availability of having the DEM of the area. The metric will be used for developing a composite index for characterizing the topography of the burned area.

Road network density

Total road network (paved and unpaved) per area unit (m/ha)

Meteorology

The following meteorological information will try to grasp the influence of the weather conditions on the size of each fire.

Canadian Fire Weather Index (FWI),

The Canadian Fire Weather Index is a well known index used broadly around the globe. It is able to incorporate simultaneously the effect of many meteorological factors (past rain, wind, relative humidity, etc.)

Rain occurrence (RAIN_OCC)

Rain occurrence (RAIN_OCC) refers to rainfall received after the start of the fire, while firefighting is still going on,over all the burning area or over part of it. It can be classified in the range 0-2 as follows:

RAIN_OCC=0: No rain fell before fire control (i.e. during FF_DURATION)

RAIN_OCC=1: There was some rain that stopped parts of the fire perimeter

RAIN_OCC=2: There was sufficient rain that had a major role in fire control

It should be noted that any information on the quantity of rain (mm) received may be noted in the text description (e.g. there was heavy rain at 08:00 of 23/7/2018 which put out the fire over the eastern flank; the quantity of rain was measured at 55 mm at the weather station RRRR at a distance of 60 km eastwards of the fire) but it will not be a standard feature in this database because it would have the potential to introduce uncertainties (which weather station the data come from, how representative is it (e.g. different elevation), how was the rain distributed spatially, etc.).

Standard Meteorological data

It is desirable to have standard Meteorological data from the closest weather station in the form shown below. This dataset can be very useful when trying to critically explain the results that will be produced from the analysis of the database. Additionally, they may allow development of additional meteorological variables (e.g. trial of various thresholds or combination of thresholds of temperature, relative humidity and wind, etc.)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	MAX RH	MIN RH	RAIN	WIND SPEED	HIGH	TIME	DOM DIR
01	27.1	32.9	15:30	20.9	06:40	81	41	0.0	5.6	24.1	12:40	WNW
02	27.6	33.3	17:40	21.6	05:30	76	37	0.0	5.5	17.7	11:40	WNW
03	29.4	36.7	15:00	22.6	06:50	70	20	0.0	5.2	20.9	12:00	WNW
04	29.5	35.6	13:40	22.4	06:10	63	31	0.0	4.4	17.7	11:40	WNW
05	30.1	38.1	16:50	24.2	03:00	71	28	0.0	6.7	24.1	12:30	WNW
06	28.6	32.8	17:00	23.8	06:30	72	47	0.0	5.9	19.3	14:50	WNW
07	28.6	34.0	16:00	22.9	06:20	70	38	0.0	6.3	19.3	11:40	WNW
08	26.6	31.8	16:30	20.9	23:50	91	50	6.0	5.6	22.5	11:50	WNW
09	25.3	30.4	15:50	19.4	06:40	91	47	0.0	6.7	22.5	02:00	WNW
10	27.0	31.5	18:50	22.0	06:20	79	35	0.0	7.3	29.0	12:10	WNW
11	27.6	32.5	16:30	22.4	03:40	72	34	0.0	7.4	25.7	10:30	W
12	29.4	36.3	17:30	24.3	06:30	71	29	0.0	7.7	27.4	11:50	SW
13	29.5	37.6	16:30	22.6	04:50	74	29	0.0	5.5	29.0	12:50	WNW
14	29.7	35.9	17:40	23.9	06:20	64	33	0.0	5.4	25.7	17:20	WNW
15	29.3	34.9	16:40	23.4	05:40	67	30	0.0	5.0	20.9	13:30	SE
16	29.0	35.4	14:00	23.2	06:50	67	37	0.0	6.7	29.0	13:50	WNW
17	30.3	38.5	16:20	23.3	06:20	63	25	0.0	9.5	33.8	20:30	WNW
18	30.4	35.7	16:30	26.6	06:30	67	33	0.0	10.4	40.2	02:00	WNW
19	30.0	35.8	14:50	23.4	05:50	68	27	0.0	9.4	33.8	18:50	NW
20	29.2	34.1	15:20	23.9	06:30	70	36	0.0	5.7	22.5	00:00	SE
21	29.7	35.8	14:00	23.3	06:40	69	38	0.2	5.5	20.9	16:20	WNW
22	30.4	39.6	15:10	23.4	05:20	73	22	0.0	5.7	32.2	14:50	E
23	31.9	38.2	14:50	27.9	23:50	54	25	0.0	16.7	78.9	16:20	WNW
24	27.6	30.7	17:30	24.8	07:40	71	43	0.0	6.6	33.8	00:10	W
25	27.9	32.8	18:20	23.2	06:00	74	39	0.0	6.4	27.4	13:00	NW
26	25.0	31.6	12:00	19.2	17:10	96	50	41.4	7.3	48.3	16:30	WNW
27	25.6	30.9	17:00	19.6	02:50	85	53	0.8	5.1	20.9	16:10	WNW
28	28.4	33.9	15:30	24.3	04:00	73	44	0.0	8.4	29.0	16:40	WNW
29	26.4	33.3	13:50	21.4	21:10	90	42	4.8	8.6	40.2	15:20	WNW
30	27.7	33.8	16:10	21.7	02:00	90	44	0.2	5.3	22.5	15:50	WNW
31	28.2	33.9	14:50	23.6	04:50	76	45	0.0	5.5	27.4	13:10	WNW