The July - August 2021 Wildfires in Greece

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The 25th issue of the Newsletter of Environmental, Disaster, and Crises Management Strategies refers to the August 2021 wildfires in Greece. It comprises the outcome of the fruitful collaboration and knowledge sharing between geologists, geographers, physicists, meteorologists, biologists, civil engineers and firefighters interested in monitoring and mapping the effects of the July and August 2021 in several areas in Greece.

- results of a recent study related to why the Mediterranean Region is a climatic hot spot for forest fires,

- the fire fighting means of Greece and the forest fire statistics for the last 20 years in Greece,

- the response actions including alert Messages from the European Emergency Phone Number 112 and the activation of the EU Civil Protection Mechanism,

- burned areas and burn severity mapped with the use of ESA Copernicus Sentinel-2 images and high resolution satellite images (PlanetScope),

- the daily evolution of the fires,

- land use, geological and geomorphological properties of the fire-affected areas,

- the impact of fires on:
  - the people including effects on public health and evacuation of residential areas
  - vegetation and wild animals
  - properties including buildings, cultivations, plantations etc,
  - infrastructures including communications, electricity and water supply networks and elements of the fire protection system (tanks)
  - vehicles including various types

based on co- and post- fire field surveys in the fire affected areas,
• the ambient particulate air pollution observed in fire-affected areas,

• the composite daily anomalies of the surface air temperature in fire-affected areas,

• the emergency response actions for the financial support of the fire-affected local population,

• the impact of fires on mental health during the response to the emergency and the recovery phase comprising individual reactions, possible and common symptoms and early psychosocial support strategies,

• the impact of fires on public health during the response to the emergency and the recovery phase referring to the chemicals found in wildfire smoke, the particulate matter exposure, the clinical and sub-clinical impacts of wildfire smoke, the exposure through inhalation,

• the differences between symptoms from smoke exposure and COVID-19,

• the specific strategies to reduce exposure to wildfire smoke,

• the respiratory protection for wildfire smoke and ash and

• the potential post-fire hazards and risks including erosion, landslides and floods creating an imperative need for an immediate multiparametric and interdisciplinary research.
The 25th issue of the Newsletter of Environmental, Disaster, and Crises Management Strategies comes for the first time in an additional, fully on-line version.

Apart from the electronic pdf version of the Newsletter issue, this innovative approach is using the ESRI ArcGIS Hub platform, which is integrating all the advantages of modern digital technology and Geographic Information Systems. The final product is interactive, easily accessible and renewable.

Using smart and responsive layouts, templates and tools, the platform includes interactive maps and multimedia content that can be configured to better showcase the available information.

Almost all of the content of this Issue is available at https://arcg.is/eTeP5.

Furthermore this hub includes interactive time-enabled maps, videos, before-and-after swipes etc.
WILDFIRES IN GREECE DURING JULY AND AUGUST 2021

The catastrophic forest fires that hit Greece, and the Mediterranean in general, in August 2021 are undoubtedly associated with the fierce heatwaves in intensity and duration recorded in Greece and the wider geographic region.

Considering that three of the main climatic factors associated with forest fires are air temperature, precipitation and soil moisture, it is interesting to simulate the values that they may reach in the coming climatic period in Greece.

For this purpose, the "ensemble simulation" technique was applied, according to which for each time step the average value of estimates is obtained from a variety of climate models. Table 1 presents both the general circulation models (GCM) and the regional climate models (RCM) used for the dynamic downscaling.

<table>
<thead>
<tr>
<th>General Circulation Models</th>
<th>Regional Climate Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNRM-CERFACS-CNRM-CM5</td>
<td>CCLM4-8-17</td>
</tr>
<tr>
<td>ICHEC-EC-EARTH</td>
<td>ALADIN53</td>
</tr>
<tr>
<td>IPSL-IPSL-CM5A-LR</td>
<td>HIRHAM5</td>
</tr>
<tr>
<td>MOHC-HadGEM2-ES</td>
<td>RACMO22E</td>
</tr>
<tr>
<td>MPI-M-MPI-ESM-LR</td>
<td>ALARO-0</td>
</tr>
<tr>
<td>NCC-NorESM1-M</td>
<td>RCA4</td>
</tr>
<tr>
<td>NOAA-GFDL-GFDL-ESM2G</td>
<td>HIRHAM5</td>
</tr>
<tr>
<td>MIROC-MIROC5</td>
<td>RACMO22E</td>
</tr>
<tr>
<td>IPSL-IPSL-CM5A-MR</td>
<td>COSMO-crCLIM-v1-1</td>
</tr>
<tr>
<td></td>
<td>ALADIN63</td>
</tr>
<tr>
<td></td>
<td>HadREM3-GA7-05</td>
</tr>
<tr>
<td></td>
<td>REMO2009</td>
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<td>REMO2015</td>
</tr>
<tr>
<td></td>
<td>WRF361H</td>
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<td></td>
<td>WRF381P</td>
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</tbody>
</table>
WHY THE MEDITERRANEAN REGION IS A CLIMATIC HOT SPOT FOR FOREST FIRES?

It should be mentioned that bias correction was applied to all simulations. Simulations that ignore this step are of limited reliability as climate simulations present different statistical characteristics from observations, leading to systematic errors in estimating the impact of climate change.

According to the climatic simulations carried out (at grid size 12.5 km x 12.5 km) in the framework of a research study* of the National and Kapodistrian University of Athens in collaboration with the Organization for Studies and Research diANEOsis:

- the average annual temperature, as based on the Representative Concentration Pathway (RCP) 8.5 trajectory for greenhouse gas concentrations, is expected to show an increase of up to 2.6 degrees Celsius throughout the country. In the summer months, the increase may reach 3.4 degrees Celsius, mainly in southern Greece.

- the decrease of precipitation also for RCP 8.5, reaches up to 30% during the summer months in many areas of Greece, mainly from Central Greece and further south (next figure). Precipitation is also expected to decrease, although at lower rate, during the winter months, which is perhaps of more concern as it has been statistically observed that in areas where precipitation is limited during the winter, forest fires are more devastating during the following summer.

- the reduction of soil moisture, for all RCPs, is significant throughout the country, although it is higher in Attica, the Peloponnese and Crete.

* Results presented here, are part of an unpublished research study of the National and Kapodistrian University of Athens and Dianeosis.
WHY THE MEDITERRANEAN REGION IS A CLIMATIC HOT SPOT FOR FOREST FIRES?

Precipitation change (%) for the summer months for the period 2046-2065 as compared to the period 1971-2000. Results refer to the application of RCP 8.5.
WHY THE MEDITERRANEAN REGION IS A CLIMATIC HOT SPOT FOR FOREST FIRES?

To the above factors are added the estimates for the increase of the intensity, frequency and mainly the duration of the heat waves, that is factors that result in extremely dry flammable material, which in turn contributes to the easy and rapid spread of forest fires and especially to the difficulty of extinguishing.

It is therefore obvious that Greece, like the rest of the Mediterranean countries, has to deal with an explosive mix of climatic conditions leading to more and more aggressive forest fires, with consequences for the natural environment, monuments located near or in forest areas, agriculture / livestock and the countryside in general and its activities. Consequences also related to tourism as well as to regional and national development in general.
WILDFIRES IN GREECE DURING JULY AND AUGUST 2021
DETECTION OF FIRE-AFFECTED AREAS

In the 20 days period (27 July to 16 August 2021) more than 910,000 acres of burned land have been detected by satellite mission of Sentinel-2 in the country of Greece.
In 2007, after a test phase of 5 years during which different national fire danger indices were implemented in EFFIS, the EFFIS network adopted the Canadian Forest Fire Weather Index (FWI) System as the method to assess the fire danger level in a harmonized way throughout Europe.

However, given the different climatic conditions in Europe, EFFIS publishes two indicators that provide information on the local/temporal variability of the FWI compared to a historical series of approximately 30 years. These indicators are the ranking, which provides percentiles of occurrence of the values, and the anomaly, computed as a standard deviation from the 30-year historical mean values. These indices are available in the pull down menu of the fire danger section.

Currently, the fire danger forecast module of EFFIS provides access to fire danger indices using numerical weather forecast from two deterministic models i.e. ECMWF (8 km) and MeteoFrance (10 km), and one probabilistic model, the ECMWF Probabilistic model, at 18 km spatial resolution.

ECMWF and MeteoFrance deterministic models

FWI is computed from the ECMWF model (8 km), which provides 1 to 9 days forecasts, and from the MeteoFrance model (10 km), which provides up to 3 days forecasts. The Fire Weather Index is mapped in 6 classes (very low, low, medium, high, very high and extreme). The fire danger classes are the same for all countries and maps show a harmonized picture of the spatial distribution of fire danger level throughout Europe, Middle East and North Africa.

ECMWF Probabilistic model

The ECMWF Probabilistic model provides four fire danger indices: (1) FWI Extreme Forecast Index (FWI EFI), (2) FWI Shift of Tails (FWI SOT), (3) Fine Fuel Moisture Content Extreme Forecast Index (FFMC EFI) and (4) Fine Fuel Moisture Content Shift of Tails (FFMC SOT).
FIRE DANGER FORECAST FOR NORTHERN EVIA
FOR 3 AUGUST 2021

Fire Danger Forecast based on the Fire Weather Index (FWI) computed from the ECMWF model (8 km)
Snapshot from the European Forest Fire Information System (EFFIS)
> EFFIS Applications > Current Situation Viewer
FIRE DANGER FORECAST FOR NORTHERN EVIA
FOR 3 AUGUST 2021

High to very extreme fire danger in northern Evia

Fire Danger Forecast based on the Fire Weather Index (FWI) computed from the MeteoFrance model (10 km)
Snapshot from the European Forest Fire Information System (EFFIS)
> EFFIS Applications > Current Situation Viewer
FIRE DANGER FORECAST FOR ATTICA
FOR 3 AUGUST 2021

Fire Danger Forecast based on the Fire Weather Index (FWI) computed from the ECMWF model (8 km)
Snapshot from the European Forest Fire Information System (EFFIS)
> EFFIS Applications > Current Situation Viewer
FIRE DANGER FORECAST FOR ATTICA
FOR 3 AUGUST 2021

Fire Danger Forecast based on the Fire Weather Index (FWI) computed from the MeteoFrance model (10 km) Snapshot from the European Forest Fire Information System (EFFIS)
> EFFIS Applications > Current Situation Viewer
Fire Danger Forecast for Peloponnese for 3 August 2021

Fire Danger Forecast based on the Fire Weather Index (FWI) computed from the ECMWF model (8 km)
Snapshot from the European Forest Fire Information System (EFFIS)
> EFFIS Applications > Current Situation Viewer
FIRE DANGER FORECAST FOR PELOPONNESE
FOR 3 AUGUST 2021

High to very extreme fire danger in Peloponnese

Fire Danger Forecast based on the Fire Weather Index (FWI) computed from the MeteoFrance model (10 km)
Snapshot from the European Forest Fire Information System (EFFIS)
> EFFIS Applications > Current Situation Viewer
In 2019, the Fire Brigade personnel consisted of 17065 people:

- 11174 were permanent personnel of the Fire Brigade dealing also with structural fires.
- 2492 were personnel employed with a five years contract.
- 1374 were seasonal personnel, hired for forest fire suppression activities.
- A further 108 civil service staff and 1912 volunteer fire fighters were also involved.

The Fire Brigade of Greece has a total of 3336 vehicles of various types. These vehicles are distinguished as follows:

- 1955 firefighting vehicles
- 981 helping vehicles
- 236 special vehicles
- 164 motor cycles

As regards aerial means participating in the 2019 campaign:

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
<th>Availability 2019 (max)</th>
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<tbody>
<tr>
<td>Aircraft CL-415</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Aircraft CL-215</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>Aircraft PEZETEL</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Helicopter SUPER PUMA AS 332 L1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Helicopter BK 117 CL</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Helicopter CHINOOK</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Aircraft C-130</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
<td>42</td>
</tr>
</tbody>
</table>

Leased air means

<table>
<thead>
<tr>
<th>Type</th>
<th>Availability 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium Press Helicopters</td>
<td>12</td>
</tr>
<tr>
<td>Heavy Duty Helicopters</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
</tr>
</tbody>
</table>

From San-Miguel-Ayanz et al. (2020); Forest fires in Europe, Middle East and North Africa
FOREST FIRE STATISTICS FOR THE PERIOD 2000-2019 IN GREECE

(a) Burnt areas, (b) number of fires and (c) average fire size in Greece from 2000 to 2019.

From San-Miguel-Ayanz et al. (2020); Forest fires in Europe, Middle East and North Africa
RESPONSE ACTIONS

ALERT MESSAGES FROM THE EUROPEAN EMERGENCY PHONE NUMBER 112

About the European Emergency Phone Number 112

In July 1991 the Council of the European Union adopted a decision regarding the pan-European emergency phone number 112. According to the decision the Members States were requested to introduce 112, free of charge, to offer emergency services more accessible, especially for travelers. It was foreseen that the single European emergency number 112 would operate alongside the existing national emergency numbers in most countries and would not directly replace them. Furthermore, a joint Directive of the European Parliament and of the European Council issued on 11 December 2018 requires that, as of June 2022, public authorities should be able to use mobile networks to alert the population through 112 for an ongoing crisis or an upcoming threat.

112 in Greece

The 112 service in Greece was fully activated in its incoming and outgoing components on January 1, 2020, after a 10-month trial period. Until August 2021, 112 was used by the Hellenic General Secretary for Civil Protection (GSCP) as a mean of alert messaging and instructions distribution in several emergency instances related to earthquakes, wildfires, floods, severe weather phenomena, COVID-19, dangerous gas leak and tsunami.

3 https://twitter.com/112Greece
RESPONSE ACTIONS
ALERT MESSAGES FROM THE EUROPEAN EMERGENCY PHONE NUMBER 112

112 during August 2021 Wildfires in Greece

Between July 28 and August 16, 76 alert messages using 112 have been issued by the Hellenic General Secretary for Civil Protection to several areas of Greece being at that time in risk of wildfire, the text of which was written in both Greek and English. 66 of them called citizens located in areas approached by wildfire to evacuate, giving specific direction (a). 8 of them instructed people located in the wider wildfire area to be on standby and follow the instructions of the authorities or to close doors, windows and chimneys, in order to prevent sparks entering the buildings (b). Furthermore, as the wildfire forecast has been set to the highest level for Rhodes Island (on August 4) and for a large part of the country, and to high or medium level risk for all the rest areas (c), two more informative and directive 112 message has been sent on August 4 to Rhodes and 5 to the whole Greek territory (d).

Indicative 112 alert messages calling near-to-fire areas (a) to evacuate to a certain direction and (b) to secure buildings from sparks. (c) Wildfire risk forecast map for August 6, 2021, (d) General instruction message of August 5 calling citizens to avoid any actions that may cause a fire.
RESPONSE ACTIONS
ALERT MESSAGES FROM THE EUROPEAN EMERGENCY PHONE NUMBER 112

Based on data retrieved from the 112 Greece twitter account (alert messages, timestamp, locations), a time aware 2D webmap is created, to interactively display the alert messages that have been issued for the wildfires between July 27 and August 16, 2021 along with the burned areas mapped using Sentinel-2 based on Burn Severity Index by the members of the Earth Observation Team of the Harokopio University of Athens, Department of Geography. The timeline can be reached at https://arcg.is/eTeP5.
BACKGROUND OF THE EU CIVIL PROTECTION MECHANISM

The EU Civil Protection Mechanism strengthens cooperation between and among Member States and Participating States in the field of civil protection, with a view to improving prevention, preparedness and response to disasters. Through the Mechanism, the European Commission plays a key role in coordinating the response to disasters in Europe and beyond.

When the scale of an emergency overwhelms the response capabilities of a country, it can request assistance via the Mechanism. Once activated, the Mechanism coordinates assistance made available by its Participating States through spontaneous offers. In addition, the EU has created the European Civil Protection Pool to have a critical number of readily available civil protection capacities allowing for a stronger and coherent collective response. Should the emergency require additional, life-saving assistance, the rescEU reserve can be sent as a matter of last resort.

To date, all EU Member States participate in the Mechanism, as well as Iceland, Norway, Serbia, North Macedonia, Montenegro and Turkey.

Since its inception in 2001, the EU Civil Protection Mechanism has responded to over 420 requests for assistance inside and outside the EU.

HOW DOES THE EU CIVIL PROTECTION MECHANISM WORK?

Natural or man-made disaster inside or outside the EU

Affected country requests assistance from the Mechanism through the Emergency Response Coordination Centre (ERCC)

Once the affected country has accepted the offers...

Member States and Participating States offer assistance, such as personnel and equipment

ERCC coordinates the deployment and delivery of assistance

ERCC may deploy a team of EU Civil Protection experts

Assistance delivered, experts return.

End of the emergency response

Available at: https://ec.europa.eu/echo/sites/default/files/mechanism_how_en.jpg
EUROPEAN CIVIL PROTECTION AND HUMANITARIAN AID OPERATIONS RELATED TO FOREST FIRES

The fire risk is expected to further increase due to climate change. It will be increasingly characterized by massive fires that cost lives and burn areas that take longer to fully recover. Between 2007 and 2020, 20% of all requests for assistance through the EU Civil Protection Mechanism were in response to forest fires.

When national response capacities are overwhelmed by fire intensity, the State can activate the EU Civil Protection Mechanism to ask for a coordinated, rapid and effective international response. When fires of such magnitude occur, EU Member States and participating states regularly show solidarity by sending assistance in the form of firefighting planes, helicopters, firefighting equipment, and teams.

In addition to the response, the EU supports and complements prevention and preparedness efforts of these States by focusing on areas where a joint European approach is more effective than separate national actions. These include risk assessments to identify the disaster risks across the EU, encouraging research to promote disaster resilience and reinforcing early warning tools.

Prevention, preparedness and response work hand in hand to save human lives and limit the further spread of fires. Having experienced forest fire experts, well-trained firefighters, technology and other assets available near the location of action makes a difference. While the national and regional authorities of these States manage forest fire prevention, preparedness and response activities, the EU can co-finance and coordinate further support when needed.

More details in the following links:

https://ec.europa.eu/echo/what-we-do/civil-protection/forest-fires_en


https://ec.europa.eu/echo/what/civil-protection/mechanism_en

https://ec.europa.eu/echo/what/civil-protection/resceu_en
In order to deal more effectively with the fires that have struck Greece since early August 2021, the General Secretariat for Civil Protection, by order of the Deputy Minister of Civil Protection and Crisis Management, activated from the first moment (3 August, at 21.30 local time) the European Civil Protection Mechanism (RescEU).

The response of the EU and the member states of the Mechanism was immediate, while in addition, a number of states rushed to assist the country bilaterally.

Cyprus, France, Croatia, Sweden, Romania, Spain, Checz Republic, Germany, Poland, Slovakia, Austria, UK, Moldova, Serbia, Switzerland, Ukraine, Russia, USA, Kuwait, Qatar, United Arab Emirates, Egypt and Israel assisted Greek authorities and staff in tackling the August 2021 fires.

From
https://www.civilprotection.gr/sites/default/gscp_up loads/files/gscp20210809_0.pdf
MEGAFIRES IN GREECE AND EU RESPONSE
EU-COUNTRIES

Based on official announcements of the General Secretariat of Civil Protection in Greece, the following countries responded to the request of Greece to fight the August 2021 megafires (information as of 10 August):

- **Cyprus**: 2 Air-Tractors and 40 firefighters
- **France**: 3 aircrafts, 243 firefighters, 59 vehicles
- **Croatia**: 1 Canadair
- **Sweden**: 2 aircrafts (Air Tractors)
- **Romania**: 108 firefighters, 21 vehicles
- **Spain**: 1 Canadair
- **Checz Republic**: 34 firefighters, 13 vehicles
- **Germany**: 221 firefighters, 46 vehicles
- **Poland**: 143 firefighters, 46 vehicles
- **Slovakia**: 75 firefighters, 30 vehicles
- **Austria**: 36 firefighters, 15 vehicles

https://www.civilprotection.gr/sites/default/gscp_uploads/files/gscp20210809_0.pdf
MEGAFIRES IN GREECE AND WORLDWIDE RESPONSE
NON-EU AND OTHER COUNTRIES

Based on official announcements of the General Secretariat of Civil Protection in Greece, non-EU and other countries around the world also responded:

- **UK**: 21 firefighters
- **Moldova**: 25 firefighters, 4 firefighting vehicles
- **Serbia**: 3 helicopters, 34 firefighters, 13 firefighting vehicles
- **Switzerland**: 3 helicopters
- **Ukraine**: 100 firefighters
- **Russia**: 2 Ilyushin-76 aircrafts, 2 Mi8 helicopters
- **USA**: 1 aircraft
- **Kuwait**: 40 firefighters, equipment
- **Qatar**: 66 firefighters, 3 firefighting vehicles
- **United Arab Emirates**: 1 aircraft, equipment
- **Egypt**: 2 helicopters
- **Israel**: 16 firefighters and 2 Air-Tractors

https://www.civilprotection.gr/sites/default/gscp_uploads/files/gscp20210809_0.pdf
MEGAFIRES IN GREECE AND RESPONSE
ONE OF THE LARGEST EVER EUROPEAN DEPLOYMENTS OF FIREFIGHTERS AND AIRCRAFTS IN HISTORY

Taking into account the previous numbers of countries and the personnel involved in response and firefighting in Greece in early August 2021, it is concluded that the EU has mobilized one of the largest ever European deployments of firefighters and aircrafts in history.

In total, 25 firefighting aircrafts, 1202 firefighters and 250 vehicles from 23 countries around the world participated in the battle for tackling the wildfires in Greece.

As regards the EU countries, 9 firefighting aircrafts, 900 firefighters and 230 vehicles from 11 countries assisted the Greek authorities. As regards the non-EU and other countries worldwide, 16 firefighting aircrafts, 302 firefighters and 20 vehicles join efforts in several raging fires in Greece during August 2021.

From
https://www.civilprotection.gr/sites/default/gscp_up loads/files/gscp20210809_0.pdf

https://twitter.com/GSCP_GR/status/1425792275506941955
MEGAFIRES IN GREECE AND RESPONSE
ONE OF THE LARGEST EVER EUROPEAN DEPLOYMENTS OF FIREFIGHTERS AND AIRCRAFTS IN HISTORY

Photo credit to the General Secretariat of Civil Protection
https://twitter.com/GSCP_GR/status/1425792275506941955
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ONE OF THE LARGEST EVER EUROPEAN DEPLOYMENTS OF FIREFIGHTERS AND AIRCRAFTS IN HISTORY

Photo credit to the General Secretariat of Civil Protection
https://twitter.com/GSCP_GR/status/1425792275506941955
MEGAFIRES IN GREECE AND RESPONSE
ONE OF THE LARGEST EVER EUROPEAN DEPLOYMENTS OF FIREFIGHTERS AND AIRCRAFTS IN HISTORY

From various internet sources
MEGA FIRES IN GREECE AND RESPONSE
ONE OF THE LARGEST EVER EUROPEAN DEPLOYMENTS OF FIREFIGHTERS AND AIRCRAFTS IN HISTORY
BURNED AREA MAPPING USING SATELLITE IMAGES

The mapping of burned areas and their burn severity was performed with the use of ESA Copernicus Sentinel-2 images and high resolution satellite images (PlanetScope). The differential Normalized Burn Ratio (NBR) and the differential Normalized Difference Vegetation Index (NDVI) methods were used for mapping of burned areas.

The NBR method is calculated as:

\[ \text{NBR} = \frac{\text{NIR} - \text{SWIR}}{\text{NIR} + \text{SWIR}} \]

The pre-event NBR and post-event NBR were used for the calculation of dNBR (differential NBR) and RBR (Relativized Burn Ratio). This allowed for the identification of the areas affected by the fire as well as an estimation of the impact’s severity.

Healthy vegetation has very high near-infrared reflectance and low reflectance in the shortwave infrared portion of the spectrum. Burned areas on the other hand have relatively low reflectance in the near-infrared and high reflectance in the shortwave infrared band. A high NBR value generally indicates healthy vegetation while a low value indicates bare ground and recently burned areas.

The NDVI method is calculated as:

\[ \text{NDVI} = \frac{\text{NIR} - \text{RED}}{\text{NIR} + \text{RED}} \]

The pre-event NDVI and post-event NDVI were used for the calculation of dNDVI (differential NDVI). This allowed for the identification of the burned scar and digitization of the burned area.
Burn or Fire Severity is the degree of the impact that a fire has on an ecosystem and is measured by organic matter loss. It is a direct impact of the fire severity and results in Ecosystem responses, such as erosion and vegetation recovery, and in societal impacts such as the loss of lives and the destruction of properties. It is a very important variable in evaluating the potential for natural regeneration and further post-fire vegetation restoration and management.
A wildfire started on Tuesday 3 August 2021, in Ano Varympompi, located in the northern sector of Attica Region, specifically on the foothills of Parnitha mountain. It burnt large forests, wildland–urban interfaces, rural and urban areas.

The mapping of burned areas and their burn severity was performed with the use of:

- two Copernicus Sentinel-2 L2A images:
  - a Pre-event image: 29/07/2021 and
  - a Post-event image: 08/08/2021)

- two PlanetScope images:
  - a Pre-event image: 02/08/2021 and

In addition, Corine Land Cover 2018 data were utilized for the identification of the burned land cover types.

A total area of 79,334 acres (based on Sentinel-2) was burned and it is mostly characterized by Moderate-High burn severity (57.28 %). The burned areas are predominantly transitional woodland-shrub (24.17 %) and mixed forest (22.16 %).
The fire affected areas host a well-developed drainage systems part of which are draining urban areas. Two main hydrographic systems exist in wider area of Varympompi fire affected area. Oinoi river which flows towards Marathon and Kifissos river which flows towards western suburbs of Attica. In the wider area of Vilia a drainage system crosses for about 11 Km the fire affected area in a direction E-W and finally ends up at Eleusina area. Smaller catchments passing through the fire affected area flows towards Nea Peramos.

The table describes quantitatively the morphological slopes distribution for the fire affected areas shown in the upper right map, while the upper left map depicts the geographical distribution of morphological slopes in Attica region.

<table>
<thead>
<tr>
<th>Slope</th>
<th>km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4°</td>
<td>28.38</td>
</tr>
<tr>
<td>4-10°</td>
<td>44.28</td>
</tr>
<tr>
<td>10-30°</td>
<td>81.37</td>
</tr>
<tr>
<td>&gt;30°</td>
<td>0.84</td>
</tr>
</tbody>
</table>
THE AUGUST 2021 WILDFIRES IN ATTICA
GEOLOGY OF THE FIRE-AFFECTED AREA

Legend

Quaternary
- Alluvial deposits
- Scree and talus cones

Neogene
- Lacustrine, fluvio-lacustrine, terrestrial and lacustrine-terrestrial formations

Sub-Pelagonian Unit
- Flysch
- Upper cretaceous transgressive limestones
- Limestones (and locally dolomites)
- Permo-Triassic clayey arenaceous rocks with limestones intercalations

Alepovouni-Afidne Unit
- Low grade marble
- Low grade metaclastic formation

Agios Georgios Unit
- Marble
- Schists, quartzite and metabasite with metachert marble intercalations

NE Attica Unit
- Neritic marble sequence
- Schist, quartzite, metabasites and acid meta-volcanics
- Blue-gray marble intercalations

- Lake
- Burned area (Planetscope)

Simplified geological – lithological map of Varympompi area
THE AUGUST 2021 WILDFIRES IN ATTICA
EXTENT OF THE FIRE-AFFECTED AREA BASED ON HIGH RESOLUTION SATELLITE IMAGES

Attica wildfire 09 August 2021 Burned Areas
using high resolution satellite images (Planetscope)
based on differential NDVI (02/08/2021-09/08/2021)

Legend
- Burned area
- Settlements

Total Burned Area: 76,361 acres
THE AUGUST 2021 WILDFIRES IN ATTICA
BURN SEVERITY MAP

Attica August 2021 Burned Areas

Legend
Burned areas according to Burn Severity
- Low Severity
- Moderate - Low Severity
- Moderate - High Severity
- High Severity

Total Burned Area:
79,334 km²

<table>
<thead>
<tr>
<th>Burn Severity</th>
<th>Area (Km²)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>11,589</td>
<td>14.52</td>
</tr>
<tr>
<td>Moderate - Low</td>
<td>21,994</td>
<td>27.72</td>
</tr>
<tr>
<td>Moderate - High</td>
<td>45,447</td>
<td>57.28</td>
</tr>
<tr>
<td>High</td>
<td>0.304</td>
<td>0.38</td>
</tr>
</tbody>
</table>

Burned Area mapping and classification according to Burn Severity.
Satellite Images of Copernicus Sentinel-2 Mission were utilized.

Pre-event Image: Sentinel-2B L2A 29/7/2021 09:05 EEST
Post-event Image: Sentinel-2B L2A 8/8/2021 09:05 EEST

Projection:
WGS 1984 UTM Zone 34N
August 2021
THE AUGUST 2021 WILDFIRES IN ATTICA
LAND COVER MAP BASED ON CORINE LAND COVER 2018

Attica August 2021, Corine Land Cover 2018 over Burned Areas

Legend
CLC 2018
- Continuous urban fabric
- Discontinuous urban fabric
- Industrial or commercial units
- Road and rail networks and associated land
- Airports
- Sport and leisure facilities
- Olive groves
- Pastures
- Complex cultivation patterns
- Land principally occupied by agriculture, with significant areas of natural vegetation
- Broad-leaved forest
- Coniferous forest
- Mixed forest
- Sclerophyllous vegetation
- Transitional woodland-shrub
- Inland marshes
- Water bodies

<table>
<thead>
<tr>
<th>LU/LC</th>
<th>Area (ha)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous urban fabric</td>
<td>0.010</td>
<td>0.01%</td>
</tr>
<tr>
<td>Discontinuous urban fabric</td>
<td>0.3</td>
<td>7.93%</td>
</tr>
<tr>
<td>Industrial or commercial units</td>
<td>0.21</td>
<td>0.26%</td>
</tr>
<tr>
<td>Road and rail networks and associated land</td>
<td>0.37</td>
<td>0.34%</td>
</tr>
<tr>
<td>Airports</td>
<td>0.23</td>
<td>0.29%</td>
</tr>
<tr>
<td>Sport and leisure facilities</td>
<td>0.50</td>
<td>0.63%</td>
</tr>
<tr>
<td>Olive Groves</td>
<td>0.067</td>
<td>0.01%</td>
</tr>
<tr>
<td>Pastures</td>
<td>0.33</td>
<td>0.16%</td>
</tr>
<tr>
<td>Complex cultivation patterns</td>
<td>0.32</td>
<td>10.73%</td>
</tr>
<tr>
<td>Land principally occupied by agriculture,</td>
<td>0.05</td>
<td>10.13%</td>
</tr>
<tr>
<td>with significant areas of natural vegetation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broad-leaved forest</td>
<td>3.6</td>
<td>4.53%</td>
</tr>
<tr>
<td>Coniferous forest</td>
<td>13.2</td>
<td>15.36%</td>
</tr>
<tr>
<td>Mixed forest</td>
<td>17.6</td>
<td>22.16%</td>
</tr>
<tr>
<td>Sclerophyllous vegetation</td>
<td>2.32</td>
<td>2.92%</td>
</tr>
<tr>
<td>Transitional woodland-shrub</td>
<td>19.3</td>
<td>24.17%</td>
</tr>
<tr>
<td>Inland marshes</td>
<td>0.23</td>
<td>0.29%</td>
</tr>
<tr>
<td>Water bodies</td>
<td>0.1</td>
<td>0.13%</td>
</tr>
</tbody>
</table>

Corine Land Cover 2018 over Burned Areas in Attica
Satellite images of Copernicus Sentinel-2 Mission were utilized.

Projection: WGS 1984 UTM Zone 34N
August 2021

Pre-event Image: Sentinel-2B L2A 29/7/2021 09:05 EEST
Post-event Image: Sentinel-2B L2A 8/8/2021 09:05 EEST
THE AUGUST 2021 WILDFIRES IN ATTICA
EVOLUTION OF THE FIRE AND AFFECTED RESIDENTIAL AREAS

Burned areas (Copernicus EMS) along with 112 alert messages locally issued by the Hellenic General Secretary for Civil Protection. The timeline can be reached at https://arcg.is/eTeP5
THE AUGUST 2021 WILDFIRES IN ATTICA
EVOLUTION OF THE FIRE AND AFFECTED RESIDENTIAL AREAS

Burned areas (Copernicus EMS) along with 112 alert messages locally issued by the Hellenic General Secretary for Civil Protection. The timeline can be reached at https://arcg.is/eTeP5
PRE-FIRE AND POST-FIRE IMAGERY
THE FIRE-AFFECTED ADAMES AREA (NORTHERN ATTICA)

Pre-fire (Google Earth)  Post-fire (Drone Imagery)
PRE-FIRE AND POST-FIRE IMAGERY
THE FIRE-AFFECTED TATOI AREA (NORTHERN ATTICA)
THE AUGUST 2021 WILDFIRES IN ATTICA
IMPACT ON VEGETATION, REGENERATION AND EROSION MITIGATION

It is obvious that in the case of Varympompi the situation was very complex due to the fact that many houses were built inside a thick forest, so when fire started it was very difficult to cope with it.

The land cover was mainly consisted of Pinus halepensis forest of mature trees with thick understory.

Regardless of the fire severity and as long as the burned trees and their cones remain on the site, the forest will naturally regenerate.

Of course, after such a disaster it is a great opportunity to re-plan the wildland - urban interface, so to avoid future similar events.

As far as it concerns the impact of fire on animals, we cannot say many as we don’t have detailed data. However, the season of the fire allows us to be rather optimistic, as no newborns would have been on the nests and soil dwelling animals would have migrated deeply in the soil seeking for better moisture conditions.

Regarding the need of constructing log dams or branch barriers so to halt potential soil erosion, this should be very carefully foreseen in steep slopes and especially in those forest patches which did not have any understorey shrubby plants. The reason is that the lack of these shrubs which normally resprout vigorously after fire will leave the burned soil uncovered and hence susceptible to leaching and erosion.
As far as it concerns the other affected areas of **North Eastern Attica**, the situation of the forest ecosystems could be characterized as similar to the one described before, with the only difference that fire has also affected some patches with cultivations, where special care should be given for their restoration and people compensation.

Regarding **Tatoi**, it is suggested that if this area is going to be used as a sort of museum and park, special care should be given to its preventive protection against fires.

Overall, the North Eastern Attica disaster could have been avoided as the area is in the periphery of **Parnitha National Park**, an area part of Natura 2000 network, which is our obligation to preserve. Preventive measures should have been applied there.
THE AUGUST 2021 WILDFIRES IN ATTICA

BOUNDARIES OF THE FIRE AFFECTED AREA IN VARYMPOMPI (NORTHERN ATTICA)

Boundaries of the fire affected area of Varympompi with the use of UAV. The flight took place on 4 August outside the settlement due to the curfew in the area imposed by the order of the public authorities.
Some vegetation patches have remained unburned in the boundaries of the fire-affected area. Monitoring and processing with the use of aerial observations (drone imagery).
In several patches the canopy has partially burned
Views of fire-affected buildings with reinforced concrete frame and infill walls in Adames area. Their roof was burnt and subsequently collapsed. The collapse resulted in burning of the building interior and damage to the equipment of the household.
Buildings with common features and fire-induced damage. The upper floors were affected by the fire due to the presence of high trees in its surroundings. The damage ranged from color change in the external part of the walls to total collapse of the roof. The presented damage is mainly attributed to firebrands attack and/or flame contact.
THE AUGUST 2021 WILDFIRES IN ATTICA IMPACT ON BUILDINGS IN TATOI AREA (NORTHERN ATTICA)

1. Destruction of external and internal combustible contents of buildings caused by firebrands attack, radiant heat exposure and/or flame contact.
2. Collapse of the roof
3. Change of color in external walls from fire.
Burned cars and trucks. Melting of the aluminum, wheel rims and car glasses is indicative of the high temperatures developed during the course of the fire.
Ambient particulate air pollution (less than 10 μm or 2.5 μm, or 1.0 μm in diameter, hereafter PM10 and PM2.5 PM1.0, respectively) recorded in Heraklio, Attica, during the period August 01-15, 2021, in the framework of ENVICARE project. Extreme high concentrations appears on August 04, 2021 due to the wildfire in Attica. PMs consist of a mixture of solid particles and liquid droplets found in the air and come in many sizes and shapes and can be made up of hundreds of different chemicals, such as sulfur dioxide and nitrogen oxides. PMs could serve as carrier of viruses, and spread them at long distances as a vector, enhancing the deposition of the virus in the lungs.
The figure shows the 500 hPa isobaric level (gpdm; colour palette) and mean sea level pressure (hPa) on August 04, 2021, 12:00 UTC, based on GFS reanalysis. The anticyclonic circulation established at the south west of Greece resulted in the advection of hot air masses from the northern Africa towards Greece, causing the third and longer lasted heat wave, during summer 2021.
The figure shows the 2m air temperature (°C) on August 04, 2021, 12:00 UTC, based on GFS reanalysis. The heat wave influences the majority of Greece. According to the Hellenic National Meteorological Service, the maximum air temperature recorded in Tatoi station (very close to Varympompi where the wildfire burst out) reached 42.6 °C, while 46.3 °C in Argos city.
The figure shows the composite daily anomaly of the surface air temperature (K) on August 04, 2021, with respect to 1981-2021 climatology, based on NCEP-NCAR reanalysis. A climatic anomaly of the surface air temperature, higher than 8 K, is obvious especially in the wider area of Attica region and Cyclades Islands complex.
The figure shows the composite daily anomaly of the surface vector wind (m/s) on August 04, 2021, with respect to 1981-2021 climatology, based on NCEP-NCAR reanalysis. There is not any climatic anomaly in the surface vector wind, in the majority of Greek area.
Northern Evia is occupied by Late Paleozoic to Mesozoic rocks of the Internal Hellenides that originate from the Pelagonian domain and the Axios-Vardar ocean.

These are covered by extensive Neogene deposits of late Miocene to Pliocene age. Their total thickness exceeds 500m.
The fire affected area is characterized by abrupt slopes, downcutting erosion and dense drainage system.
Most of the drainage basins are small with short hydrographic networks but there are few big drainage basins covering important part of the fire affected area ending up at Gouves, Rovies, Neochori and Krya Vrisi.
A wildfire started on Tuesday 3 August 2021, in North Evia, close to Mantoudi settlement. It burnt large forests, rural and urban areas.

The mapping of burned areas was produced with the use of:

- two Copernicus Sentinel-2 L2A images
  - Pre-fire image: 01/08/2021 and
  - Post-fire image: 11/08/2021)

based on differential normalized burning ratio (NBR) formula.

A total burned area is around to 471,233 acres.

Burn severity is mainly characterized as high (45%).

The burned vegetation is consisted of coniferous (31%) and mixed (21.30 %) forest.
THE AUGUST 2021 WILDFIRES IN NORTHERN EIVA ISLAND
EXTENT OF THE FIRE-AFFECTED AREA BASED ON HIGH RESOLUTION SATELLITE IMAGES

Evia wildfire 11 August 2021 Burned Areas using Sentinel-2 based on differential NBR (01/08/2021-11/08/2021)

Legend
- Burned area
- Settlements

Total Burned Area: 471.233 acres
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA ISLAND
BURN SEVERITY MAP

Evia August 2021 Burned Areas

Legend
Burned areas according to Burn Severity
- Low Severity
- Moderate-Low Severity
- Moderate-high Severity
- High Severity

Total Burned Area: 471.233 acres

<table>
<thead>
<tr>
<th>Burn Severity</th>
<th>Area (acres)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>25060</td>
<td>5.30</td>
</tr>
<tr>
<td>Moderate-low</td>
<td>82641,1</td>
<td>17.49</td>
</tr>
<tr>
<td>Moderate-high</td>
<td>151195,1</td>
<td>31.99</td>
</tr>
<tr>
<td>High</td>
<td>213708</td>
<td>45.22</td>
</tr>
</tbody>
</table>

Burned area mapping and classification according to Burn Severity.
Contains modified Sentinel-2 Copernicus data 2021.
Pre-Event image: Sentinel-2A L2A 01/08/2021
Post-Event image: Sentinel-2A L2A 11/08/2021

Projection:
WGS 1984 UTM Zone 34N
August 2021
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA ISLAND
LAND COVER MAP BASED ON CORINE LAND COVER 2018

Evia August 2021 Corine Land Cover 2018 over Burned Areas

Legend
CLC 2018
- Beaches, dunes, sands
- Broad-leaved forest
- Complex cultivation patterns
- Coniferous forest
- Discontinuous urban fabric
- Irrigated meadows
- Land principally occupied by agriculture, with significant areas of natural vegetation
- Mineral extraction sites
- Mixed forest
- Non-irrigated arable land
- Olive groves
- Sclerophyllous vegetation
- Sparsely vegetated areas
- Sport and leisure facilities
- Transnational woodland-shrub

LU/LC | Area (acres) | Percentage |
--- | --- | --- |
Discontinuous urban fabric | 351,1 | 0.07 |
Mineral extraction sites | 803,6 | 0.17 |
Spot and leisure facilities | 60,1 | 0.01 |
Non-irrigated arable land | 15379,2 | 3.26 |
Olive groves | 26822,3 | 5.69 |
Complex cultivation patterns | 21356,4 | 4.53 |
Land principally occupied by agriculture, with significant areas of natural vegetation | 76929,6 | 16.14 |
Broad-leaved forest | 23842,1 | 5.06 |
Coniferous forest | 146167,1 | 31.02 |
Mixed forest | 106406,3 | 21.31 |
Sclerophyllous vegetation | 12046,2 | 2.56 |
Transnational woodland-shrub | 40360,4 | 0.87 |

Burned area mapping and classification according to Burn Severity.
Contains modified Sentinel-2 Copernicus data 2021.

Pre-Event image: Sentinel-2A L2A 01/08/2021
Post-Event image: Sentinel-2A L2A 11/08/2021

Projection: WGS 1984 UTM Zone 34N
August 2021
TIME SERIES OF THE EVIA WILDFIRE SPREADING
WITH HIGH SPATIAL (3m), SPECTRAL (B-G-R-IR), TEMPORAL (DAILY) RESOLUTION PLANETSCOPE SATELLITE IMAGES

4-8-2021

5-8-2021

7-8-2021

8-8-2021
TIME SERIES OF THE EVIA WILDFIRE SPREADING WITH HIGH SPATIAL (3m), SPECTRAL (B-G-R-IR), TEMPORAL (DAILY) RESOLUTION PLANETSCOPE SATELLITE IMAGES
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA ISLAND
EVOLUTION OF THE FIRE AND AFFECTED RESIDENTIAL AREAS

Burned areas (Copernicus EMS) along with 112 alert messages locally issued by the Hellenic General Secretary for Civil Protection. The timeline can be reached at https://arcg.is/eTeP5
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA ISLAND
EVOLUTION OF THE FIRE AND AFFECTED RESIDENTIAL AREAS
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA
BOUNDARIES OF THE FIRE AFFECTED AREAS

Ayia Anna

Limni
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA
BOUNDARIES OF THE FIRE AFFECTED AREA

Rovies

Kirinthos
The firefighters opened new fire breaks in the forest in order to protect the residential areas.
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA IMPACT ON BUILDINGS IN AYIA ANNA

Views of fire-affected buildings with reinforced-concrete frame and infill walls. Destruction and collapse of roof was caused by firebrands attack, radiant heat exposure and/or flame contact.
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA
IMPACT ON BUILDINGS IN AYIA ANNA

Views of fire-affected buildings with reinforced-concrete frame and infill walls. Destruction of external and internal combustible contents of buildings caused by firebrands attack, radiant heat exposure and/or flame contact. Buildings suffered partial collapse of their walls.
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA
IMPACT ON CAMPING FACILITIES IN COASTAL AYIA ANNA

Destruction of external and internal combustible contents of the camping of Ayia Anna, which is close to the beach. Facilities were surrounded by pine forest.
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA
IMPACT ON INFRASTRUCTURES AND LIFE LINES IN AYIA ANNA

Indicative views of the fire-induced damage in the low and medium voltage distribution networks comprising cut cables
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA IMPACT ON VEHICLES IN AYIA ANNA

Burned cars, motorbikes and bikes. The melting of the aluminum, wheel rims and the car glasses is indicative of the high temperatures developed during the course of the fire.
Destruction of external and internal combustible contents of the building at the entrance of the Limni village. The wood material of the upper floor is among the most affected parts of the structure.
The fire-induced damage to roofs is easily detectable by using UAV and processing related data. A characteristic example from Limni village is presented. Damage ranged from destruction of roof tiles to total collapse of the roof.
The fire-induced damage to roofs is easily detectable by using UAV and processing related data. A characteristic example from Ayia Anna village is also presented.

[1] Destruction and collapse of external roof
[2] Partial collapse of the building
[3] Total collapse of the building
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA ISLAND
IMPACT ON VEGETATION IN AYIA ANNA AND ROVIES

Olive groves remained intact within the fire-affected area
The fire that was burning over Evia Island for more than 8 days has mainly affected *Pinus halepensis* forests. The forests in their majority were consisted of mature trees which were bearing adequate canopy seed bank, from which natural regeneration of the pines will take place.
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA ISLAND IMPACT ON PLANTATIONS

Intermixed with the forest were olive plantations for the restoration of which special care should be given.
It seems that fire severity was quite heterogeneous, but in general the canopy has remained on the trees, a fact indicating that the fire was quickly moving and fire severity was moderate.
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA ISLAND IMPACT ON VEGETATION IN KECHRIES – LIMNI AREA

▲ Kecrhies – Limni road: Thick understorey – moderate burning. Burned shrubs of the understorey should not be removed as they will very quickly start resprouting contributing to soil erosion prevention.

▲ In areas like this one in Kechries – Limni road the forests looks younger so maybe less regeneration is expected here. Patches like this one should be identified within the periphery of fire burn and special attention should be given for ensuring adequate regeneration.
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA ISLAND IMPACT ON VEGETATION IN LIMNI AND ROVIES AREAS

Patches of thick forest burned, reburned and cultivations close to Limni village

Mature forest to Rovies: In areas like this one, with steep slopes, selective logging could be applied and log erosion barriers could be placed parallel to the contours to prevent leaching and erosion.
A general view of the Rovies area. It is obvious that fire has affected both forested areas (example: orange circle) and olive groves (example: red circle). It is also evident that some shrubby patches have been completely consumed (yellow circle).
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA ISLAND IMPACT ON VEGETATION

According to the 2st evaluation performed by ΥΛΗ, an environmental studies office (https://forest.gr/), the total burned area is approximately 51,2032 ha of which 32,2189 ha in Municipality of Limni – Mantoudi- Ayia Anna (63%) and the remaining in the Municipality of Istiaia – Aidipsos.

According to the existing Forest Map of Evoia, the amount of forest and forested areas burned equals 37,9393 ha which consist 74.1% of the total area burned.

Of the total area of forests and forested areas of local communities affected by the fire in the Municipality of Limni - Mantoudi - Ayia Anna, a percentage of 77.20% was burned, while the respective percentage in the Municipality of Istiaia – Aidipsos amounts to 79.46%. It is characteristic that in most communities this percentage exceeds 90% and reaches up to 100% of the existing forests and forest areas.

In the following table, the area burned by vegetation type and land cover is provided.
## The August 2021 Wildfires in Northern Evia Island
Vegetation and Land Cover Types Burned Per Municipality of Evoia

<table>
<thead>
<tr>
<th>Vegetation type/ land cover</th>
<th>Municipality of Limni - Mantoudi - Agia Anna (acres)</th>
<th>Municipality of Istria - Aedipsos (acres)</th>
<th>Total (acres)</th>
<th>Percentage of the total burned area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinus halepensis</td>
<td>185.979,91</td>
<td>114.287,60</td>
<td>300.266,51</td>
<td>58.64</td>
</tr>
<tr>
<td>Pinus nigra</td>
<td>6.017,67</td>
<td>7.911,88</td>
<td>13.929,55</td>
<td>2.72</td>
</tr>
<tr>
<td>Abies cephalonica</td>
<td>8.545,39</td>
<td>1.028,14</td>
<td>9.573,53</td>
<td>1.87</td>
</tr>
<tr>
<td>Shrublands</td>
<td>3.485,31</td>
<td>979,88</td>
<td>4.465,19</td>
<td>0.87</td>
</tr>
<tr>
<td>Grasslands / open shrublands</td>
<td>2.999,43</td>
<td>103,43</td>
<td>3.102,86</td>
<td>0.61</td>
</tr>
<tr>
<td>Oaks</td>
<td>792,54</td>
<td>1.524,03</td>
<td>2.316,57</td>
<td>0.45</td>
</tr>
<tr>
<td>Riverine vegetation</td>
<td>996,59</td>
<td>515,19</td>
<td>1.511,77</td>
<td>0.30</td>
</tr>
<tr>
<td>Chestnuts</td>
<td>37,78</td>
<td>0,00</td>
<td>37,78</td>
<td>0.01</td>
</tr>
<tr>
<td>Cultivations</td>
<td>102.124,42</td>
<td>60.701,66</td>
<td>162.826,08</td>
<td>31.80</td>
</tr>
<tr>
<td>Abandoned fields</td>
<td>8.422,78</td>
<td>1.737,66</td>
<td>10.160,44</td>
<td>1.98</td>
</tr>
<tr>
<td>Houses</td>
<td>1.776,08</td>
<td>736,42</td>
<td>2.512,50</td>
<td>0.49</td>
</tr>
<tr>
<td>Bare ground</td>
<td>1.008,03</td>
<td>316,20</td>
<td>1.324,23</td>
<td>0.26</td>
</tr>
<tr>
<td>TOTAL</td>
<td>322.184,95</td>
<td>189.842,06</td>
<td>512.027,01</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

From [https://forest.gr/](https://forest.gr/)
THE AUGUST 2021 WILDFIRES IN NORTHERN EVIA ISLAND IMPACT ON VEGETATION, REGENERATION AND EROSION MITIGATION

Overall, and regardless of the fire severity and as long as the burned trees and their cones remain on the site, the forest will naturally regenerate.

Regarding the regeneration of the endemic fir forest, it is imperative that any unburned patch will be very carefully preserved so to ensure its natural regeneration. The same holds for black pine forests too.

Regarding the need of constructing log dams or branch barriers so to halt potential soil erosion, this should be very carefully foreseen in steep slopes and especially in those forest patches which did not have any understorey shrubby plants. The reason is that the lack of these shrubs which normally respout vigorously after fire will leave the burned soil uncovered and hence susceptible to leaching and erosion.

As far as it concerns the impact of fire on wild animals, we cannot say many as we don’t have detailed data. However, the season of the fire allows us to be rather optimistic, as no newborns would have been on the nests and soil dwelling animals would have migrated deeply in the soil seeking for better moisture conditions.
In the Peloponnesian area four main fire outbreaks were observed in Aegialea, Ancient Olympia, Diavolitsi and East Mani. The fire-affected area is characterized by high elevations and steep morphological slopes that are shown in the upper left and right map, respectively. In the area of Ancient Olympia and East Mani a well-developed drainage system is observed in contrast to the area of Aegialea and Diavolitsi. Within a short time, fire-affected areas will have a profound effect on erosion rates and their simultaneous increase. The table below describes quantitatively the morphological slopes distribution for the fire affected areas shown in the upper right map.

<table>
<thead>
<tr>
<th></th>
<th>Slope (°)</th>
<th>Km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ancient</td>
<td>0-4</td>
<td>7.17</td>
</tr>
<tr>
<td></td>
<td>4-10</td>
<td>20.74</td>
</tr>
<tr>
<td></td>
<td>10-30</td>
<td>69.92</td>
</tr>
<tr>
<td></td>
<td>&gt;30</td>
<td>37.21</td>
</tr>
<tr>
<td>Aegialea</td>
<td>0-4</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>4-10</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>10-30</td>
<td>1.26</td>
</tr>
<tr>
<td></td>
<td>&gt;30</td>
<td>0.85</td>
</tr>
<tr>
<td>Diavolitsi</td>
<td>0-4</td>
<td>1.53</td>
</tr>
<tr>
<td></td>
<td>4-10</td>
<td>5.26</td>
</tr>
<tr>
<td></td>
<td>10-30</td>
<td>29.30</td>
</tr>
<tr>
<td></td>
<td>&gt;30</td>
<td>11.19</td>
</tr>
<tr>
<td>East Mani</td>
<td>0-4</td>
<td>7.21</td>
</tr>
<tr>
<td></td>
<td>4-10</td>
<td>11.04</td>
</tr>
<tr>
<td></td>
<td>10-30</td>
<td>49.88</td>
</tr>
<tr>
<td></td>
<td>&gt;30</td>
<td>36.59</td>
</tr>
</tbody>
</table>
The fire-affected area in the Western Aegialeia is entirely composed of post-alpine deposits including Pliocene - Pleistocene blue marls and yellow sandy clays with loose conglomerates in places as well as Quaternary deposits comprising talus cones, scree and alluvial deposits. The Quaternary deposits occur along the coastal part of the affected area (e.g. Kamares, Lampiri and Logos areas), while the Pliocene-Pleistocene formation in the semi-mountainous area (e.g. area of Ziria village). The area is controlled by NW-SE striking faults of the Corinth Gulf. Neos Erineos fault along with the coastal Lampiri fault are the major tectonic structures in the fire-affected area, resulting in intense morphology and steep slopes. They are considered active since c. 0.4 Ma (From Gawthorpe et al., 2018)
A wildfire started on Saturday July 31 in **Western Aegialeia**, near the settlements of Lampiri, Ziria and Kamari. It burned rural areas, houses and forested areas.

The **mapping of burned areas** and their **burn severity** were performed with the use of:

- two Copernicus Sentinel-2 L2A images:
  - a Pre-event image: 27/07/2021
  - a Post-event image: 01/08/2021.

In addition, Corine Land Cover 2018 data were utilized to identify the burned land cover types.

**A total area of 3,172 Acres was burned.** It is mostly characterized by **moderate-high burn severity** (34.9%).

The burned vegetation is predominantly **transitional woodland-shrub** (21.86%) and **olive groves** (17.18%).

Additionally, **land near the road and railway network was also affected** (5.41%).
THE AUGUST 2021 WILDFIRES IN WESTERN AEGEALIA
BURN SEVERITY MAP

Achaea July - August 2021 Burned Areas

Legend

- Settlements
- Burned areas according to Burn Severity
  - Low Severity
  - Moderate - Low Severity
  - Moderate - High Severity
  - High Severity

Total Burned Area:
3.172 Km²

<table>
<thead>
<tr>
<th>Burn Severity</th>
<th>Area (Km²)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.997</td>
<td>31.4</td>
</tr>
<tr>
<td>Moderate - Low</td>
<td>1.064</td>
<td>33.6</td>
</tr>
<tr>
<td>Moderate - High</td>
<td>1.106</td>
<td>34.9</td>
</tr>
<tr>
<td>High</td>
<td>0.004</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Burned Area mapping and classification according to Burn Severity.
Satellite Images of Copernicus Sentinel-2 Mission were utilized.
Pre-event image: Sentinel-2A L2A 27/07/2021
Post-event image: Sentinel-2A L2A 01/08/2021

Projection:
WGS 1984 UTM Zone 34N
August 2021
THE AUGUST 2021 WILDFIRES IN WESTERN AEGIALLEIA
LAND COVER MAP BASED ON CORINE LAND COVER 2018

Achaea July - August 2021 Land Cover of Burned Areas

Legend

- 122: Road and rail networks and associated land
- 221: Vineyards
- 222: Fruit trees and berry plantations
- 223: Olive groves
- 242: Complex cultivation patterns
- 243: Land principally occupied by agriculture, with significant areas of natural vegetation
- 312: Coniferous forest
- 324: Transitional woodland-shrub

<table>
<thead>
<tr>
<th>Corine Land Cover</th>
<th>Area (Km²)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>122</td>
<td>0.17</td>
<td>5.41</td>
</tr>
<tr>
<td>221</td>
<td>0.24</td>
<td>7.64</td>
</tr>
<tr>
<td>222</td>
<td>0.7</td>
<td>22</td>
</tr>
<tr>
<td>223</td>
<td>0.54</td>
<td>17.18</td>
</tr>
<tr>
<td>242</td>
<td>0.13</td>
<td>4.25</td>
</tr>
<tr>
<td>243</td>
<td>0.28</td>
<td>8.75</td>
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<tr>
<td>312</td>
<td>0.41</td>
<td>12.91</td>
</tr>
<tr>
<td>324</td>
<td>0.7</td>
<td>21.86</td>
</tr>
</tbody>
</table>

Land Cover mapping of Burned Areas.
Corine Land Cover 2018 was utilized.
Pre-event image: Sentinel-2A L2A 27/07/2021
Post-event image: Sentinel-2A L2A 01/08/2021

Projection: WGS 1984 UTM Zone 34N
August 2021
THE AUGUST 2021 WILDFIRES IN ACHAIA REGIONAL UNIT
EVOLUTION OF THE FIRE IN WESTERN AEGIALEIA

The fire in Western Aegialeia, located in the eastern part of the Achaia Regional Unit, started at noon (12:25 local time) on 31 July 2021. It spread out of control for hours affecting forested areas, cultivations, houses, cars and businesses, as it passed through residential areas.

Two messages were sent to residents by the 112 Emergency Communications Service. The first one was sent at 14:35 (local time) and informed people in Ziria, Kamares and Lampiri of Achaia regional unit to evacuate immediately towards Aegion city. Then, the fire spread northeastwards, to Logos area, resulting in a second message from 112 service. It was sent at 17:45 (local time) and informed people in Logos area to evacuate towards Aegion city. In addition to the evacuation of settlements, a children's camp in Lampiri was also evacuated. More specifically, 110 children were transported by bus accompanied by Greek Police patrols to a safer place in the adjacent Patras city.

In addition to the ground and air firefighting efforts and 112 messages, a firefighting boat was also mobilized and contributed to the evacuation of residents from the coastal affected areas. In addition, the Hellenic Coast Guard as well as individuals were mobilized and assisted to the evacuation. A Disaster Management Unit (EMAK in Greece) was also present in order to help residents where needed. 110 residents in the Aegialeia, Bouka, Logos and Pefki area were rescued from the Hellenic Coast Guard vessels and transported to the Aegion city port. A ferry boat from Rio-Antirrio lines was also on alert, in case a larger number of trapped people needed to be transported.

During the event, fire spread close to a part of the Athens – Patras highway, resulting in the temporary disruption not only in this section, but also in the Rio – Antirrio Bridge (officially the Charilaos Trikoupis Bridge). Travellers who wanted to go to areas located east of the fire had to use the road leading from Nafpaktos to Itea, north of the Corinthian Gulf.
Alert messages sent by the 112 Emergency Communications Service to residents of the western Aegialeia because of the wildfire on 31 July 2021. Residents were informed to evacuate areas due to raging wildfire towards the adjacent Aegion City.
THE AUGUST 2021 WILDFIRES IN WESTERN AEGIALIA
MOBILIZATION OF HEALTH UNITS AND IMPACT ON HEALTH

Due to the spreading of the fire through residential areas, all health units of the wider area were put on full alert. The General Hospital of Eastern Achaia in Aegion City, the General University Hospital of Patras and the Patras General Hospital "Ayios Andreas" along with their medical and nursing staff were immediately mobilized, while the National Center for Emergency Assistance was also on alert.

Due to the dense fire smoke, residents in Kato Ziria village presented respiratory problems and a mobile unit of the National Center for Emergency Assistance reached the area in order to provide first aid and medical treatment. Two unit of the National Center for Emergency Assistance were also sent to Aegion city.

15 residents were taken to the General Hospital of Eastern Achaia in Aegion City, who encountered respiratory problems. Seven of them remained hospitalized for precautionary reasons (six residents and one port officer), while the rest left.

A man, who suffered a hand burn while trying to save his house in Ziria village, was also admitted to the Patras General Hospital "Ayios Andreas". He underwent successful plastic surgery and is being treated without further health problems.

An ambulance crew of the National Center for Emergency Assistance in the port of Aegion city carried out a preventive examination of 38 people, who disembarked from the Hellenic Coast Guard vessels, after being transported from the adjacent coastal areas.
In Ziria, fire spread through the village, causing damage to homes and crops. The majority of the fire-affected houses in the village were holiday homes. Only one was a permanent residence. The family, who lived in it, moved in a safe place in Patras city.
THE AUGUST 2021 WILDFIRES IN WESTERN AEGEAN SEA IMPACT ON BUILDINGS IN LAMPIRI COASTAL AREA

All facilities and buildings in the abandoned Club Méditerranée along the coastal Lampiri were destroyed. The majority of buildings were of bangalow type with wooden non-structural parts.
Due to fire, all flammable materials were vanished and the concrete frame and brick walls are now the only standing parts, also severely affected by the intense fire.
The vegetation of the coastal area of Lampiri was mainly consisted of pine and cypress trees (Photo credit to K. Gertzos, https://www.youtube.com/watch?v=muuiHQqLw4c&t=5s)
The vegetation of the Lampiri coastal area was mainly of pines (*Pinus halepensis*). The fire was not so intense to burn the canopy which is still on the scorched trees.
THE AUGUST 2021 WILDFIRES IN WESTERN AEGLALEIA
IMPACT ON CULTIVATIONS

The fire caused great damage to olive groves and vineyards in the fire-affected Ziria village. The raisin production was also severely affected.
THE AUGUST 2021 WILDFIRES IN WESTERN AEGEALIA
BOUNDARIES OF THE FIRE AFFECTED AREA – UAV (DRONE) DATA

The use of UAV contributes to the delineation of the burned area …
THE AUGUST 2021 WILDFIRES IN WESTERN AEGEALIA
BOUNDARIES OF THE FIRE-AFFECTED AREA BY USING UAV (DRONE) DATA

... and of vegetation patches remained intact within the fire-affected area
THE AUGUST 2021 WILDFIRES IN ACHAIA REGIONAL UNIT
EVOLUTION OF THE FIRE IN WESTERN PANACHAIOKO

At noon on 28 July 2021, a fire broke out in the area of Elekistra village, at the western front of Panachaiko Mt, on the eastern outskirts of Patras city. The fire broke out in a forestry area and spread to Karia area, while it also threatened Neo Souli village. Due to the spread of the fire, the competent authorities ordered the evacuation of Neo Souli and Riganokampos.

The health structures and the National Center for Emergency Assistance were put in a state of maximum readiness. In particular, the General University Hospital of Patras and the Patras General Hospital "Ayios Andreas".

Two firefighters and a resident of the Elekistra area were taken to the hospital with respiratory problems. In addition, first aid was provided to a resident of the area at the Health Center of the southern sector of Patras. Fortunately, their condition was not a cause of concern.

For safety reasons, the traffic on the perimeter road of Patras was temporarily disrupted, since a large part of the road was located near the fire front.
THE AUGUST 2021 WILDFIRES IN ACHAIA
GEOLGY OF THE FIRE-AFFECTED AREA IN WESTERN PANACHAIKO

The fire-affected area in the western front of Panachaiko Mt is characterized by intense relief with steep slopes associated with the Karia-Krini and the Romanos active fault zones (Mavroulis, 2009). The fire-affected area is composed of post-alpine deposits. In particular, Pleistocene marine and lacustrine deposits and Holocene deposits comprising scree and alluvial deposits within river beds are also observed.

The alpine deposits are mainly observed in the eastern part of the fire-affected area and they entirely belong to the Pindos geotectonic unit. From bottom to top, they mainly comprise of Jurassic - Lower Cretaceous radiolarites, Upper Cretaceous limestones and flysch of Upper Cretaceous - Paleocene.

The Pindos formations have been affected by the presence of the fault zone and instability conditions are observed in several sites along the fault zone. The most impressive unstable area is the Koutsoupies site, where slope failures were generated in 1962, in 1999 and 2001.

From Mavroulis (2009)
Partial view of the Karia - Krini fault zone in the landslide site of Koutsoupies. The site has been affected by a fault with prevailing strike-slip component, as it is shown by field measurements conducted by Mavroulis (2009). Below, exposed fault surfaces in Koutsoupies landslide zone.

From Mavroulis (2009)
Slope failures generated in the Koutsoupies landslide zone in (a) 1962, (b) 1999 and (c) 2001 and mapped by Sabatakakis et al. (2005). The generated landslides were attributed to:

- the intense relief of the area with slope up to 40°.
- the presence of unstable material of previous landslides
- the presence of the impermeable flysch formations under the recent scree formation
- the oversaturation of the soil attributed to prolonged rainfalls and to the large water amount of the Pindos limestones and
- the erosion phenomena affecting scree.

The aforementioned factors have high potential to affect not only this site but several sites in the fire-affected area with possible impact on adjacent infrastructure (roads) and properties (residential buildings and fields).
Slope failures in Koutsoupies site in 1999 and 2001 (Rozos and Psonis, 1999, Sabatakakis et al., 2005). Similar events have been also recorded before 1960 and in 1962.
THE AUGUST 2021 WILDFIRES IN WESTERN PANACHAIKO
VIEW OF THE FIRE-AFFECTED AREA

The fire-affected area in the western foothills of Panachaiko is located close to the eastern suburbs of Patras city
Delineation and definition of the fire-affected area by UAV in the western front of Panachaiko Mt. Destroyed and damaged buildings are easily detected.
THE AUGUST 2021 WILDFIRES IN WESTERN PANACHALKO
IMPACT ON BUILDINGS IN KARIA VILLAGE

A building with reinforced-concrete frame and infill walls in Karia village. The external wooden and plastic elements are completely burnt resulting fire spreading to the roof, which was subsequently suffered total collapse. The fire affected also doors and windows, which are totally destroyed.
Another example of a severely fire-affected building in Karia village. All external wooden non-structural elements of the house (doors, windows, roof) are affected by the fire resulting in spreading of the fire in the internal part of the house and subsequent damage to the equipment of the house. The reinforced concrete frame and the infill walls remained almost intact.
The fire along the western front of Panachaiko Mt affected mainly olive groves. The olive trees suffered damage either by direct contact with flames or by radiant heat. Pines and planted cypress trees were also affected.
THE AUGUST 2021 WILDFIRES IN WESTERN PANACHAIKO IMPACT ON VEGETATION

Burned and unburned patches within the fire-affected area in the western front of Panachaiko Mt. By using UAV in the post-fire field surveys, the delineation of burned and intact patches within the fire-affected area is possible. Information about the affected field can be easily acquired, including its size, the type of the vegetation and the number of the affected trees in case of cultivations, among other significant information.

From the images shown it is rather obvious that the emphasis should be given to the restoration of burned cultivations. The patches of natural vegetation affected are consisted of Aleppo pine, which will naturally regenerate after the first autumn rains through the germination of seeds released after heat induced opening of their serotinous cones. In order this to take place no massive removal of the trees and their cones from the field should take place.
THE AUGUST 2021 WILDFIRES IN ACHAIA

Image by Chinese satellite GAOPHEN 1 (16m/pixel)
False color image (NIR, Red, Green)
Acquisition date: 04/08/2021
THE AUGUST 2021 WILDFIRES IN ANCIENT OLYMPIA AND GORTYNIA AREAS

The mapping of burned areas and their burn severity was performed with:

- the use of two Copernicus Sentinel-2 L2A images
  - a Pre-event image on 1/08/2021 and
  - a Post-event image on 11/08/2021

In addition, Corine Land Cover 2018 data were utilized to identify the burned land cover types.

A total area of 170,012 acres was burned and it is mostly characterized by low burn severity (44.76%).

The burned areas are predominantly land occupied by:

- agriculture (32.93%) and
- transitional woodland / shrub (13.96%).
THE AUGUST 2021 WILDFIRES IN ANCIENT OLYMPIA AND GORTYNIA AREAS
EXTENT OF THE FIRE-AFFECTED AREA BASED ON HIGH RESOLUTION SATELLITE IMAGES

Ilia wildfire 11 August 2021 Burned Areas using Sentinel-2
based on differential NBR (01/08/2021-11/08/2021)

Legend
- Burned area
- Settlements

Total Burned Area: 170.012 acres
THE AUGUST 2021 WILDFIRES IN ANCIENT OLYMPIA AND GORTYNIA AREAS
BURN SEVERITY MAP

Ilia August 2021 Burned Areas

Legend
Burned areas according to Burn Severity

- Low Severity
- Moderate - Low Severity
- Moderate - High Severity
- High Severity

Total Burned Area: 170,012 km²

Burned Area mapping and classification according to Burn Severity.

Satellite Images of Copernicus Sentinel-2 Mission were utilized.

Pre-event Image: Sentinel-2B L2A 1/8/2021 09:20 EEST

Projection: WGS 1984 UTM Zone 33N
August 2021
THE AUGUST 2021 WILDFIRES IN ANCIENT OLYMPIA AND GORTYNIA AREAS
LAND COVER MAP BASED ON CORINE LAND COVER 2018

Ilia August 2021, Corine Land Cover 2018 over Burned Areas

Legend

<table>
<thead>
<tr>
<th>CLC 2018</th>
<th>Area (Km²)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>112: Discontinuous urban fabric</td>
<td>0.268</td>
<td>0.15</td>
</tr>
<tr>
<td>211: Non-irrigated arable land</td>
<td>6.239</td>
<td>3.66</td>
</tr>
<tr>
<td>223: Olive groves</td>
<td>22.077</td>
<td>12.98</td>
</tr>
<tr>
<td>242: Complex cultivation patterns</td>
<td>16.394</td>
<td>9.85</td>
</tr>
<tr>
<td>243: Land principally occupied by agriculture, with significant areas of natural vegetation</td>
<td>55.313</td>
<td>32.93</td>
</tr>
<tr>
<td>311: Broad leaved forest</td>
<td>1.941</td>
<td>1.14</td>
</tr>
<tr>
<td>312: Mixed forest</td>
<td>4.262</td>
<td>2.51</td>
</tr>
<tr>
<td>313: Coniferous forest</td>
<td>23.366</td>
<td>13.94</td>
</tr>
<tr>
<td>323: Sclerophyllous vegetation</td>
<td>15.271</td>
<td>8.98</td>
</tr>
<tr>
<td>324: Transitional woodland-shrub</td>
<td>23.741</td>
<td>13.96</td>
</tr>
</tbody>
</table>

Burned Area mapping and classification according to Burn Severity.

Satellite Images of Copernicus Sentinel-2 Mission were utilized.

Projection: WGS 1984 UTM Zone 33N
August 2021

Pre-event Image: Sentinel-2B L2A 1/8/2021 09:20 EEST
THE AUGUST 2021 WILDFIRES IN ANCIENT OLYMPIA AND GORTYNIA AREAS
EVOLUTION OF THE FIRE AND AFFECTED RESIDENTIAL AREAS

Burned areas (Copernicus EMS) along with 112 alert messages locally issued by the Hellenic General Secretary for Civil Protection. The timeline can be reached at https://arcg.is/eTeP5
THE AUGUST 2021 WILDFIRES IN ANCIENT OLYMPIA AND GORTYNIΑ AREAS
EVOLUTION OF THE FIRE AND AFFECTED RESIDENTIAL AREAS
From the geological point of view, the Ancient Olympia - Gortynia fire-affected area is located at the northern part of the Pyrgos Olympia basin. This basin is a large graben bounded by the Erymanthos Mts horst towards N and NE, the Gortynia Mts (Tropaea) horst towards E and the Lapithas Mt horst towards S (Lekkas et al., 1992, 2000; Fountoulis et al., 2007; Mavroulis et al., 2013).

These horsts consist of alpine formations and are bounded by fault zones forming impressive morphological discontinuities (Lekkas et al., 1992, 2000; Fountoulis et al., 2007a,b; Mavroulis et al., 2013). The basin is filled with Late Miocene-Holocene deposits, with a maximum thickness of approximately 3000 m (Lekkas et al. 2000). These post-alpine deposits overlay unconformably the well-formed palaeorelief developed on the alpine formations (Lekkas et al., 2000).

The neotectonic evolution of the Pyrgos-Olympia basin was not the same in all its extent. It was influenced by the creation and evolution of smaller tectonic blocks (2nd order structures) (Lekkas et al., 1992, Mariolakos et al., 1995).

Geological map of the northwestern Peloponnese along with the major neotectonic macrostructures and the main faults. The affected area in the red frame.
THE AUGUST 2021 WILDFIRES IN ANCIENT OLYMPIA AND GORTYNIA AREAS
POST-ALPINE FORMATIONS

- Holocene marshy deposits
- Holocene dunes
- Scree
- Coastal deposits
- Alluvial deposits
- Pleistocene Erymanthos formation: conglomerates
- Pleistocene Keramidia formation: sandy and muddy clays
- Plio-Pleistocene Vounargo formation: clays, marls, mudstones, sandstones and sands with intercalations of conglomerates
- Pliocene Peristeri formation: conglomerates
- Pliocene Inoi formation: marls and sandstones
- Upper Miocene - Pliocene Platiana formation: clay, sands and pelites with lignite intercalations
- Upper Miocene - Pliocene Tsemberoulas formation: clays and pelites with intercalations of sand, lignites and conglomerates
- Upper Miocene - Pliocene Prodromos formation: conglomerates

Lekkas et al. (1992)

Fire-affected area
On 4 August (17:20, local time), the first 112 alert message for the Ancient Olympia - Gortynia fire was sent to all people in Pelopio, Platanos, Koskinas, Mageiras, Kladeos villages, which were informed to evacuate towards Pyrgos city located westwards, while people in Kafkania and Chelidoni towards Lala village.

On 4 August (18:03, local time), the second 112 message was sent to people of Ancient Olympia to evacuate to Mouria village.

On 5 August (11:22, local time), another 112 message informed people of Chelidoni village to evacuate towards Latzoi area.

On 5 August (14:36, local time), the fourth message informed residents of 9 villages (Diliza, Ano Louvro, Kato Louvro, Mouria, Pefkes, Kammena, Linaria, Villia) to evacuate towards Aspra Spitia village.

On 5 August (16:31, local time) a message informed people in Vassilaki, Ipsilo, Aspra Spitia, Xirokambos, Ambari, Ano Louvro, Kato Louvro, Kryoneri, Lala, Lasdika, Nemouta to evacuate towards Panopoulo area.

On 6 August (15:05, local time), a 112 message was sent to people of Villia, Tsapareika, Nemouta to evacuate towards Achladini.

On 7 August (17:56 local time), a 112 message was sent to people of Doukas, Milies to evacuate towards Neraida.

On 10 August, the fire reached villages of Gortynia (Arcadia). It has already passed the Erymanthos River bed and was spreading without control. The first message for evacuation in Gortynia was sent on 10 August (14:33, local time). People in Livadaki and Kapelitsa – Tripotamia villages were informed to evacuate.

Two hours later (16:23, local time), another message was sent to residents of Palaeochori, Pirris, Ayios Ioannis, Lotis, Liodora, Kastraki and Fanaraki to evacuate. A minute later (16:24, local time), another message was sent to people in Chrysochori, Loutra, Litharos, Ayioneri, Parnassos, Ochtia, Aetorrachi, Kalliani, Doxa, Toumbitsi and Melidoni villages to evacuate.
In many cases in Gortynia, the fire of August affected not only the surrounding rural areas of villages, but also the residential areas. Typical cases of heavily affected villages are Chora, Livadaki and Pyrri. The fire spread through these villages, causing severe damage to non-structural components of reinforced-concrete buildings, destruction of household equipment and damage to networks and infrastructure.
The same applies for the fire-affected area in Ilia, where fire spread through many settlements, such as Mageiras, Chelidoni Kafkania and Platanos among others.
More serious damage was observed in old masonry houses and warehouses. The fire affected not only their roofs and perimeter wooden structures, but also the quality of the masonry, affecting the structural stability of the old buildings.
THE AUGUST 2021 WILDFIRES IN ANCIENT OLYMPIA AND GORTYNIA AREAS
IMPACT ON BUSINESS EQUIPMENT

Yard, garden and outdoor equipment in houses and businesses was also severely affected by the fire. They were totally burned or melt after radiant heat exposure. At the particular establishment, all underground installations were destroyed because of subterranean heat.
THE AUGUST 2021 WILDFIRES IN ANCIENT OLYMPIA AND GORTYNIA AREAS
IMPACT ON VEGETATION IN MAGEIRAS AREA (ILIA)

The burned vegetation is mainly Aleppo pine forests and shrublands, which are expected to regenerate naturally. Regarding olive groves special attention should be given there to ensure their restoration.
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THE AUGUST 2021 WILDFIRES IN ANCIENT OLYMPIA AND GORTYNIA AREAS
IMPACT ON VEGETATION IN DAFNI AREA (GORTYNIA)

The same holds for Dafni area, where the burned vegetation is mainly Aleppo pine forests and shrublands, which are expected to regenerate naturally. Regarding olive groves special attention should be given there to ensure their restoration.
THE AUGUST 2021 WILDFIRES IN ANCIENT OLYMPIA AND GORTYNIA AREAS
IMPACT ON VEGETATION IN LIVADAKI AREA (GORTYNIA)
THE AUGUST 2021 WILDFIRES IN MESSINIA
GEOLOGY OF THE FIRE-AFFECTED AREAS IN NORTHERN AND SOUTHERN MESSINIA

Legend

Quaternary
- Alluvial deposits
- Scree and talus cones
- Fluvial facies and terraces

Neogene
- Marl and sandstones

Pindos Unit
- Flysch

Gavrovo-Tripolis Unit
- Flysch
- Limestones
- Burned area (Sentinel-2)

Pelagic limetones with intercalations of silex, marls and sandstones
Radiolarite series
Limestones and dolomites
Ophiolitic series members

2km
0.5km

N

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Issue No. 25, August 2021 | 138
A wildfire started on 4 August 2021, in Melpeia (Ano Messinia) at 16:51 (local time). Specifically, the fire burned large forests and agricultural land.

The mapping of burned areas and their burn severity was performed with the use of:

- two Copernicus Sentinel-2 L2A images
  - a Pre-event image: 01/08/2021 and
  - a Post-event image: 16/08/2021).

In addition, Corine Land Cover 2018 data were utilized to identify the burned land cover types.

A total area of 45,781 acres was burned and it is mostly characterized by moderate-high burn severity (42.23 %).

The burned vegetation is predominantly:

- transitional woodland-shrub (34.48%) and
- land principally occupied by agriculture with significant areas of natural vegetation (22.36%).

Something worth mentioning is that in the same region, according to CLC 2018, there is another area that has been burnt again before 2018 that was the release of the final version of CLC.
THE AUGUST 2021 WILDFIRES IN ANO MESSINIA – MEGALOPOLIS AREA
EXTENT OF THE FIRE-AFFECTED AREA BASED ON HIGH RESOLUTION SATELLITE IMAGES

Messinia (Melpeia) Wildfire, 16 August 2021,
Burned Areas using Sentinel-2
based on differential NBR (01/08/2021-16/08/2021)

Legend
- Settlements

Burned Area

Total Burned Area:
45.781 acres
THE AUGUST 2021 WILDFIRES IN ANO MESSINIA – MEGALOPOLIS AREA
BURN SEVERITY MAP

Messinia (Melpeia), August 2021, Burned Areas

Legend
Burned areas according to Burn Severity

<table>
<thead>
<tr>
<th>Burn Severity</th>
<th>Area (acres)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>13.683</td>
<td>29.89</td>
</tr>
<tr>
<td>Moderate – Low</td>
<td>12.409</td>
<td>27.11</td>
</tr>
<tr>
<td>Moderate – High</td>
<td>19.331</td>
<td>42.23</td>
</tr>
<tr>
<td>High</td>
<td>356</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Total Burned Area: 45.781 acres

Burned Area mapping and classification according to Burn Severity

Satellite Images of Copernicus Sentinel-2 Mission were utilized.

Projection: WGS 1984 UTM Zone 34N
August 2021

Pre-event Image: Sentinel-2B L2A 01/08/2021 09:20 EEST
Post-event Image: Sentinel-2B L2A 16/08/2021 09:20 EEST
THE AUGUST 2021 WILDFIRES IN ANO MESSINIA – MEGALOPOLIS AREA
LAND COVER MAP BASED ON CORINE LAND COVER 2018

Messinia (Melpeia), August 2021, Corine Land Cover 2018 over Burned Areas

Legend
CLC 2018
- Road and rail networks and associated land
- Olive groves
- Complex cultivation patterns
- Land principally occupied by agriculture, with significant areas of natural vegetation
- Broad-leaved forest
- Mixed forest
- Natural grasslands
- Sclerophyllous vegetation
- Transitional woodland-shrub
- Burnt areas

<table>
<thead>
<tr>
<th>LU/LC</th>
<th>Area (ha)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road and rail networks and associated land</td>
<td>534</td>
<td>1.16</td>
</tr>
<tr>
<td>Olive groves</td>
<td>3,625</td>
<td>7.22</td>
</tr>
<tr>
<td>Complex cultivation patterns</td>
<td>61</td>
<td>0.13</td>
</tr>
<tr>
<td>Land principally occupied by agriculture, with significant areas of natural vegetation</td>
<td>10,265</td>
<td>22.86</td>
</tr>
<tr>
<td>Broad-leaved forest</td>
<td>2,555</td>
<td>5.57</td>
</tr>
<tr>
<td>Mixed forest</td>
<td>1,361</td>
<td>2.97</td>
</tr>
<tr>
<td>Natural grasslands</td>
<td>2,891</td>
<td>6.28</td>
</tr>
<tr>
<td>Sclerophyllous vegetation</td>
<td>9,388</td>
<td>20.42</td>
</tr>
<tr>
<td>Transitional woodland-shrub</td>
<td>15,833</td>
<td>34.48</td>
</tr>
<tr>
<td>Burnt areas</td>
<td>410</td>
<td>0.89</td>
</tr>
</tbody>
</table>

Corine Land Cover 2018 over Burned Areas in Messinia (Melpeia)

Satellite Images of Copernicus Sentinel-2 Mission were utilized.

Pre-event Image: Sentinel-2B L2A 01/08/2021 09:20 EEST
Post-event Image: Sentinel-2B L2A 16/08/2021 09:20 EEST

Projection: WGS 1984 UTM Zone 34N
August 2021
The August 2021 wildfires in Ano Messini - Megalopolis area
Evolution of the fire and affected residential areas

Burned areas (Copernicus EMS) along with 112 alert messages locally issued by the Hellenic General Secretary for Civil Protection. The timeline can be reached at https://arcg.is/eTeP5
THE AUGUST 2021 WILDFIRES IN ANO MESSINIA – MEGALOPOLIS AREA
EVOLUTION OF THE FIRE AND AFFECTED RESIDENTIAL AREAS

Burned areas (Copernicus EMS) along with 112 alert messages locally issued by the Hellenic General Secretary for Civil Protection. The timeline can be reached at https://arcgis.esri.com/TeP5
The SW boundary of the fire affected area (orange line), approximately follows the limit between the mountainous and low land area north of the road along Agrilovouno - Diavolitsi - Dessylas villages (view to the south).

Some vegetation patches have remained unburned in the boundaries of the fire-affected area (yellow line).
The forest trees and shrubs were totally or partially burned, but some vegetation patches have remained unburned.
The fire along the southern front of Ano Messinia mountainous area affected also olive groves. The olive trees suffered damage either by direct contact with flames or by radiant heat.
THE AUGUST 2021 WILDFIRES IN ANO MESSINIA – MEGALOPOLIS AREA
IMPACT ON INFRASTRUCTURES

Car traffic was disrupted on the Kalamata – Tripolis highway for 2 days due to the fire that affected both sides of the road.

Despite its width, the highway could not function as a break, in order to tackle the fire.
The fire burned an illegal landfill near Monastiraki village (SW part of the fire-affected area), resulting in burning of plastics that continues for several days.
Deforestation due to the fire will multiply phenomena such as landslides, erosion and debris flow along the provincial road network (e.g. photos a and b, road from Agioi Theodoroi to Monastiraki village) and the highway (e.g. photo c, Tsakona bridge area).
A wildfire started on August 2, 2021, in Vasilitsi, in forested area.

The mapping of burned areas and their burn severity was performed with the use of:

- **two Copernicus Sentinel-2 L2A images:**
  - a Pre-event image on 27/07/2021 and
  - a Post-event image on 6/08/2021.

In addition, **Corine Land Cover 2018** data were utilized to identify the burned land cover types.

**A total area of 5.027 Acres was burned** and it is mostly characterized by **moderate-high burn severity** (47.98%).

The burned areas are **predominantly olive groves** (59.16%) and **sclerophyllous vegetation** (33.04%).
THE AUGUST 2021 WILDFIRES IN SOUTHERN MESSINIA AREA
EXTENT OF THE FIRE-AFFECTED AREA BASED ON HIGH RESOLUTION SATELLITE IMAGES

Vasilitsi wildfire 06 August 2021 Burned Areas using Sentinel-2 based on differential NBR (27/07/2021-06/08/2021)

Legend
- Burned area
- Settlements

Total Burned Area: 5.027 acres
THE AUGUST 2021 WILDFIRES IN SOUTHERN MESSINIA AREA
BURN SEVERITY MAP

Vasilitsi August 2021 Burned Areas

Legend
Burned areas according to Burn Severity
- Low Severity
- Moderate - Low Severity
- Moderate - High Severity
- High Severity

Total Burned Area: 5,027 km²

Burn Severity | Area (Km²) | Percentage (%)
--- | --- | ---
Low | 1,074 | 21.37
Moderate - Low | 1,499 | 29.82
Moderate - High | 2,412 | 47.98
High | 0,041 | 0.89

Burned Area mapping and classification according to Burn Severity.
Satellite Images of Copernicus Sentinel-2 Mission were utilized.

Projector:
WGS 1984 UTM Zone 33N
August 2021

Pre-event Image: Sentinel-2B L2A 27/7/2021 09:20 EEST
THE AUGUST 2021 WILDFIRES IN SOUTHERN MESSINIA AREA
LAND COVER MAP BASED ON CORINE LAND COVER 2018

Vasilitsi August 2021, Corine Land Cover 2018 over Burned Areas

Legend

<table>
<thead>
<tr>
<th>CLC Code</th>
<th>Area (Km²)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>223</td>
<td>2,974</td>
<td>59.16</td>
</tr>
<tr>
<td>242</td>
<td>0,003</td>
<td>0.07</td>
</tr>
<tr>
<td>243</td>
<td>0,388</td>
<td>7.73</td>
</tr>
<tr>
<td>323</td>
<td>1,662</td>
<td>33.04</td>
</tr>
</tbody>
</table>

Burned Area mapping and classification according to Burn Severity.
Satellite Images of Copernicus Sentinel-2 Mission were utilized.

Projection: WGS 1984 UTM Zone 33N
August 2021

Pre-event Image: Sentinel-2B L2A 27/7/2021 09:20 EEST
The forest fire in the east stopped in the coastal zone and in the south on the road from Koroni to Methoni.
The forest trees and shrubs were totally or partially burned, but some vegetation patches have remained unburned. It is also evident that some shrubby patches have been completely consumed.
The fire affected also olive groves. The olive trees suffered damage either by direct contact with flames or by radiant heat.
Views of fire-affected buildings with reinforced-concrete frame and infill walls. Destruction and collapse of roof was caused by firebrands attack, radiant heat exposure and/or flame contact.
The fire will multiply phenomena such as landslides, along the road network (e.g. road Vasilitsi – Hrisokellaria).
A wildfire started on 5 of August 2021, in eastern Mani, close to the city of Gytheio.

The mapping of burned areas and their burn severity was performed with the use of two Copernicus Sentinel-2 L2A images:

- a Pre-event image on 1/08/2021 and
- a Post-event image on 11/08/2021

A total area of 89,579 acres was burned, including rural areas, houses and forest areas.

43% of burned area was consisted of sclerophyllous vegetation.

According to burn severity map, the damage caused by wildfire was mainly moderate-low (49.90%) following by moderate-high (33.20%) and low (16.90%).
THE AUGUST 2021 WILDFIRES IN LACONIA
EXTENT OF THE FIRE-AFFECTED AREA BASED ON HIGH RESOLUTION SATELLITE IMAGES

Githio wildfire 11 August 2021 Burned Areas using Sentinel-2 based on differential NBR (01/08/2021-11/08/2021)

Legend
- Burned area
- Settlements

Total Burned Area: 89.579 acres
THE AUGUST 2021 WILDFIRES IN LACONIA
BURN SEVERITY MAP

Githio August 2021 Burned Areas

Legend
Burned areas according to Burn Severity
- Low Severity
- Moderate-Low Severity
- Moderate-high Severity
- High Severity

Total Burned Area: 89.579 acres

<table>
<thead>
<tr>
<th>Burn Severity</th>
<th>Area (acres)</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>15196</td>
<td>16,90</td>
</tr>
<tr>
<td>Moderate-low</td>
<td>44870,9</td>
<td>49,90</td>
</tr>
<tr>
<td>Moderate-high</td>
<td>29853,3</td>
<td>33,20</td>
</tr>
<tr>
<td>High</td>
<td>2,4</td>
<td>0,00</td>
</tr>
</tbody>
</table>

Burned area mapping and classification according to Burn Severity.

Contains modified Sentinel-2 Copernicus data 2021.

Pre-Event image: Sentinel-2B L2A 01/08/2021
Post-Event image: Sentinel-2B L2A 11/08/2021

Projection: WGS 1984 UTM Zone 34N
August 2021
THE AUGUST 2021 WILDFIRES IN LACONIA
LAND COVER MAP BASED ON CORINE LAND COVER 2018

Githio August 2021 Corine Land Cover 2018 over Burned Areas

Legend
CLC 2018
- Broad-leaved forest
- Complex cultivation patterns
- Coniferous forest
- Land principally occupied by agriculture, with significant areas of natural vegetation
- Mixed forest
- Natural grasslands
- Non-irrigated arable land
- Olive groves
- Sclerophyllous vegetation
- Transitional woodland-shrub

<table>
<thead>
<tr>
<th>LU/LC</th>
<th>Area (acres)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-irrigated arable land</td>
<td>5,7</td>
<td>0,01</td>
</tr>
<tr>
<td>Olive groves</td>
<td>10271,8</td>
<td>11,45</td>
</tr>
<tr>
<td>Complex cultivation patterns</td>
<td>706,6</td>
<td>0,79</td>
</tr>
<tr>
<td>Land principally occupied by agriculture, with</td>
<td>14507,6</td>
<td>16,19</td>
</tr>
<tr>
<td>significant areas of natural vegetation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broad-leaved forest</td>
<td>869,6</td>
<td>0,97</td>
</tr>
<tr>
<td>Coniferous forest</td>
<td>2,7</td>
<td>0,00</td>
</tr>
<tr>
<td>Mixed forest</td>
<td>11916,8</td>
<td>13,30</td>
</tr>
<tr>
<td>Natural grasslands</td>
<td>2716,9</td>
<td>3,03</td>
</tr>
<tr>
<td>Sclerophyllous vegetation</td>
<td>39142</td>
<td>43,68</td>
</tr>
<tr>
<td>Transitional woodland-shrub</td>
<td>9471,4</td>
<td>10,57</td>
</tr>
</tbody>
</table>

Burned area mapping and classification according to Burn Severity.

Contains modified Sentinel-2 Copernicus data 2021.

Pre-Event image: Sentinel-2B L2A 01/08/2021
Post-Event image: Sentinel-2B L2A 11/08/2021

Projection:
WGS 1984 UTM Zone 34N August 2021
THE AUGUST 2021 WILDFIRES IN ANCIENT OLYMPIA AND GORTYNIA AREAS
EVOLUTION OF THE FIRE AND AFFECTED RESIDENTIAL AREAS

Burned areas (Copernicus EMS) along with 112 alert messages locally issued by the Hellenic General Secretary for Civil Protection. The timeline can be reached at https://arcg.is/eTeP5
Based on post-fire field surveys in the fire-affected area of Laconia, it is concluded that the fire-induced building damage in most cases had to do with partial or even total destruction of the roof. The vertical collapse of the roof within the house resulted in fire spread inside the house, further destruction of the equipment and damage to non-structural elements of the building. Apart from the collapse of the roof, there was neither collapse of masonry nor total collapse of the structure.
In addition to the buildings in the fire-affected area in Laconia, the fire also affected mobile objects inside and outside forested areas, including private vehicles (cars, farm cars, vans, tractors etc) parked mainly in the surrounding of buildings but also in the fields.
The fire in Laconia caused damage to all networks, parts of which were exposed to flames, including water, electricity and telecommunications networks. More specifically, damage was caused to wooden pillars and cables of the electricity network, to mobile network antennas and to plastic or rubber pipes of the water supply and irrigation networks.
The fire caused damage to fire tanks in several sites of the affected area. Depending on the material of their construction and the severity of the fire, the damage ranged from simple discoloration of the external part of the tank to complete melting and destruction of the tank. Destruction of these reservoirs can adversely affect fire extinction efforts, especially in areas located far from other water bodies comprising sea, lakes, rivers etc.
Shrublands seem to be the main vegetation type mainly affected by the fire, although some patches with coniferous forest have been burned. Normally, both vegetation types will naturally regenerate.
Besides the natural vegetation, olive groves have been greatly affected. Special care should be paid to these patches to ensure their restoration.
The effects on beekeeping were severe. Many beehives were completely destroyed and the only thing left was the beehive top lids composed of metal, reminiscent of their original location.
The wildfire in Rhodes Island burned down a large forest and countryside areas near Psinthos village in 1 August 2021. The fire affected area is characterized by low elevation and mild morphological slopes that are shown in the upper left and right map, respectively. The hydrographic network has poor distribution. The table below describes quantitatively the morphological slopes distribution for the fire affected areas shown in the upper right map.

<table>
<thead>
<tr>
<th>Slope (°)</th>
<th>Km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>2.72</td>
</tr>
<tr>
<td>4-10</td>
<td>4.36</td>
</tr>
<tr>
<td>10-30</td>
<td>4.1</td>
</tr>
<tr>
<td>&gt;30</td>
<td>0.11</td>
</tr>
</tbody>
</table>
On August 1st, 2021 a wildfire started in Rhodes Island, Greece and more specifically close to its north edge. The moderate wind in the region made the fire very difficult to be brought under control. As a result, several settlements had been evacuated for precautional reasons.

The mapping of burned areas and the burn severity was performed with the use of ESA Copernicus Sentinel-2 images. In particular, two Sentinel-2 L2A images:

- on 28/07/2021 (pre-event) and
- on 02/08/2021 (post-event)

were used.

Moreover, the burned areas are predominantly include woodland-shrub (41.35%) and coniferous forest.

In addition, the land cover of burned areas was assessed with the use of Corine Land Cover 2018 data.

The total area of 10,593 acres was burned and is mostly characterized by moderate-high burn severity (47.37%).
THE AUGUST 2021 WILDFIRES IN RHODES ISLAND
BURN SEVERITY MAP

Rhodes August 2021 Burned Areas

Legend
Burned areas according to Burn Severity
- Low Severity
- Moderate - Low Severity
- Moderate - High Severity
- High Severity

Total Burned Area:
10,593 km²

Burn Area mapping and classification according to Burn Severity.

Satellite Images of Copernicus Sentinel-2 Mission were utilized.

Pre-event Image: Sentinel-2A L2A 28/7/2021 08:46 EEST
Post-event Image: Sentinel-2B L2A 2/8/2021 08:45 EEST

Projection:
WGS 1984 UTM Zone 35N
August 2021
THE AUGUST 2021 WILDFIRES IN RHODES ISLAND
LAND COVER MAP BASED ON CORINE LAND COVER 2018

Rhodes August 2021 CLC 2018 for the Burned Areas

Legend
CLC 2018

<table>
<thead>
<tr>
<th>LU/LC</th>
<th>Area (km²)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olive Groves</td>
<td>0.397</td>
<td>3.74%</td>
</tr>
<tr>
<td>Land principally occupied by agriculture, with significant areas of natural vegetation</td>
<td>1.296</td>
<td>12.23%</td>
</tr>
<tr>
<td>Complex Cultivation Patterns</td>
<td>0.033</td>
<td>0.33%</td>
</tr>
<tr>
<td>Coniferous Forest</td>
<td>2.890</td>
<td>27.36%</td>
</tr>
<tr>
<td>Natural Grasslands</td>
<td>1.356</td>
<td>12.81%</td>
</tr>
<tr>
<td>Sclerophyllous vegetation</td>
<td>0.253</td>
<td>2.38%</td>
</tr>
<tr>
<td>Transitional woodland-shrub</td>
<td>4.379</td>
<td>41.35%</td>
</tr>
</tbody>
</table>

Burned Area mapping and classification according to Burn Severity.
Satellite Images of Copernicus Sentinel-2 Mission were utilized.

Projection:
WGS 1984 UTM Zone 35N
August 2021

Pre-event Image: Sentinel-2A L2A 28/7/2021 08:46 EEST
Post-event Image: Sentinel-2B L2A 2/8/2021 08:45 EEST
THE AUGUST 2021 WILDFIRES IN RHODES ISLAND
EVOLUTION OF THE FIRE AND AFFECTED RESIDENTIAL AREAS

Burned areas (Copernicus EMS) along with 112 alert messages locally issued by the Hellenic General Secretary for Civil Protection. The timeline can be reached at https://arcg.is/eTeP5
The August 2021 Wildfires in Rhodes Island

Evolution of the Fire

On 1 August 2021 (14:00 local time) a fire started in Rhodes island, burning down large forest and rural areas.

The fire broke out in Soroni, behind Panagia Pantanassa. The fire front grew quickly, moving towards the famous Butterflies Valley, where authorities evacuated residents and tourists for precautionary reasons. The moderate wind and high flammability of forest fuels due to prolonged draught, made the work of firefighters very difficult.

Psinthos village and Kalamonas military camp have been evacuated for precautionary reasons. Residents in Maritsa and Kalithies received alert message to be on standby and follow the instructions of the authorities.

Fire Brigade supported by six helicopters and three planes, local authorities and volunteers put out the fire two days after.

A state of emergency has been declared in the townships of Petaloudes and Kallithea of Rhodes Island following devastating fires.
Large part of the island experienced loss of electric power and water supply as damage reported in the lifeline networks due to the wildfire. In some areas, cell phone service has also been interrupted. Crop irrigation systems were destroyed.

An ostrich farm has burned down.

Crop production was destroyed in a total area of 170 acres, of which 132 acres were olive groves and the remaining 37.8 acres were vineyards.

Most of the burned olive groves were located in the area of Theologos where the fronts of the fire broke out, while the burned vineyards were located in the area of Kalamonas.

About 500 beehives in Theologos, Maritsa and Psinthos were destroyed, while 38 productive animals were burned, as well as stored fodder.
THE AUGUST 2021 WILDFIRES IN RHODES ISLAND
FIRE EXTINGUISHING PROCESS

Extinguishing process in Rhodes Island by air and ground forces including firefighters and volunteers
THE AUGUST 2021 WILDFIRES IN RHODES ISLAND
SUPPORT BY VOLUNTEERS

Provision of food, water, equipment and care by volunteers in Rhodes
Provision of food, water, equipment and care by volunteers in Rhodes
THE AUGUST 2021 WILDFIRES IN RHODES ISLAND
FOREST COMPOSITION IN RHODES ISLAND

Pinus brutia

Cupressus sempervirens
The burned forested areas were consisted of Anatolian pine (Pinus brutia) and cypress trees (Cupressus sempervirens). Both species have natural regeneration mechanisms and they will recover their populations from seed germination from their stored canopy seed bank, provided that no other perturbation occurs, especially during the first post-fire year.
Regarding severity, it seems that fire passed quickly from the sites, leaving the tree canopy scorched and partially burned. In areas were another fire has occurred in the past, at an interval shorter than 20 years, there might be an issue. Special care should be paid on those areas.
THE AUGUST 2021 WILDFIRES IN RHODES ISLAND
IMPACT ON LIVESTOCK

The Rhodian fallow deer (*Dama dama*) is a component of the natural environment of the island, being also an element of its cultural heritage.

It seems that the species can avoid fire, as it runs away, escaping from it. The major threats it faces are from poaching and competition from livestock. Several studies have been performed on the species aiming at its protection. These studies have shown that individuals of fallow deer visit the burned sites seeking the fresh resprouts and seedlings appearing after the first autumn rains.

Photos credit: https://www.dimokratiki.gr/
THE AUGUST 2021 WILDFIRES IN RHODES ISLAND IMPACT ON BUILDINGS AND VEHICLES

Burned vehicles and ostrich farm premises
A wildfire broke out in regions of Western Macedonia, in Grevena of Greece, on 3 August 2021. Specifically, the fire broke out near the village of Felli, about 19 km SE of Grevena. The fire burned mostly fields, reeds, grasslands, and forestry areas. Though there was no threaten towards the urban areas, as a precaution, due to the intense smoke, the settlements of Agalaioi, Diporo, Kentro, Nisi, Sarakina, and Neochori were evacuated.

For the identification of the burned areas as well as for the assessment of the burn severity:

- Pre-fire (01/08/2021) and
- post-fire (09/08/2021)

**Sentinel-2 products** were used.

Moreover, **Corine Land Cover 2018** data was used so as to identify the land cover of the burned areas.

A total area of 10,100 acres was burned, mostly characterized by high burn severity (30.45%).

The burned areas constitute mainly of broad-leaved forest (81.09%) and transitional woodland-shrub (13.27%).
THE AUGUST 2021 WILDFIRES IN GREVENA
EXTENT OF THE FIRE-AFFECTED AREA BASED ON HIGH RESOLUTION SATELLITE IMAGES
THE AUGUST 2021 WILDFIRES IN GREVENA
BURN SEVERITY MAP

Burned Areas Classified According to Burn Severity

- Low Severity
- Moderate-Low Severity
- Moderate-High Severity
- High Severity

Burn Severity in Burned Areas

0 1 2Km
THE AUGUST 2021 WILDFIRES IN GREVENA
LAND COVER MAP BASED ON CORINE LAND COVER 2018

Legend
- Non-irrigated arable land
- Land principally occupied by agriculture
- Broad-leaved forest
- Transitional woodland-shrub
- Water courses
A wildfire broke out in Central Greece, in Phokida, on 5 August 2021. Specifically, the fire broke out near the village of Tolofona. Elaia and Kallithea villages were evacuated for precautionary reasons.

For the identification of the burned areas as well as for the assessment of the burn severity:

- Sentinel-2 products were used:
  - Pre-fire (01/08/2021) and
  - Post-fire (11/08/2021)

Moreover, Corine Land Cover 2018 data was used so as to identify the land cover of the burned areas.

A total area of 28,880 acres was burned, mostly composed by Moderate-high burn severity (31.47%).

The burned areas constitute mainly of sclerophyllous vegetation (55.1%) and transitional woodland-shrub (11.79%).
THE AUGUST 2021 WILDFIRES IN PHOCIDA
EXTENT OF THE FIRE-AFFECTED AREA BASED ON HIGH RESOLUTION SATELLITE IMAGES
THE AUGUST 2021 WILDFIRES IN PHOCIDA
BURN SEVERITY MAP

Burned Areas Classified According to Burn Severity

- Low Severity
- Moderate-low Severity
- Moderate-high Severity
- High Severity

Gulf of Corinth
THE AUGUST 2021 WILDFIRES IN PHOCIDA
LAND COVER MAP BASED ON CORINE LAND COVER 2018

Legend
- Discontinuous urban fabric
- Non-irrigated arable land
- Olive groves
- Complex cultivation patterns
- Land principally occupied by agriculture
- Coniferous forest
  - Mixed forest
  - Natural grasslands
  - Sclerophyllous vegetation
  - Transitional woodland-shrub
  - Beaches, dunes, sands
  - Sparsely vegetated areas
THE AUGUST 2021 WILDFIRES IN PHOCIDA
EVOLUTION OF THE FIRE AND AFFECTED RESIDENTIAL AREAS

Burned areas (Copernicus EMS) along with 112 alert messages locally issued by the Hellenic General Secretary for Civil Protection. The timeline can be reached at https://arcg.is/eTeP5
THE AUGUST 2021 WILDFIRES IN EASTERN ATTICA (LAVREOTIKI)
GEOLOGY OF THE FIRE-AFFECTED AREA
A wildfire started on August 16 2021, in Markati, at Lavreotiki region.

The **mapping of burned areas** and their **burn severity** was performed with the use of two Copernicus Sentinel-2 L2A images:

- a Pre-event image on 13/08/2021 and
- a Post-event image on 18/08/2021

In addition, **Corine Land Cover 2018** data were utilized to identify the burned land cover types.

A **total area of 5,009 acres** was burned and it is mostly characterized by **moderate-low burn severity** (48.32 %).

The burned areas are **Coniferus forest** (23.56%) areas previously repeatedly burned and now classified as **natural grasslands** (20%) and **Sclerophylous vegetation** (20%).
THE AUGUST 2021 WILDFIRES IN SOUTHEASTERN ATTICA (LAVREOTIKI)
EXTENT OF THE FIRE-AFFECTED AREA BASED ON HIGH RESOLUTION SATELLITE IMAGES

Lavreotiki wildfire 18 August 2021 Burned Areas using Sentinel-2 based on differential NBR (13/08/2021-18/08/2021)

Legend
- Burned area
- Settlements

Total Burned Area: 5,009 acres
THE AUGUST 2021 WILDFIRES IN SOUTHEASTERN ATTICA (LAVREOTIKI)
BURN SEVERITY MAP

Lavreotiki August 2021 Burned Areas

Legend
Burned areas according to Burn Severity
- Low Severity
- Moderate-Low Severity
- Moderate-high Severity
- High Severity

Total Burned Area: 5,009 acres

<table>
<thead>
<tr>
<th>Burn Severity</th>
<th>Area (acres)</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>858,9</td>
<td>16.23</td>
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<tr>
<td>Moderate-low</td>
<td>2556,6</td>
<td>48.32</td>
</tr>
<tr>
<td>Moderate-high</td>
<td>1876</td>
<td>35.46</td>
</tr>
<tr>
<td>High</td>
<td>0,1</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Burned area mapping and classification according to Burn Severity.

Contains modified Sentinel-2 Copernicus data 2021.

Projection: WGS 1984 UTM Zone 34N

Pre-Event image: Sentinel-2B L2A 13/08/2021
Post-Event image: Sentinel-2B L2A 18/08/2021
THE AUGUST 2021 WILDFIRES IN SOUTHEASTERN ATTICA (LAVREOTIKI)
LAND COVER MAP BASED ON CORINE LAND COVER 2018

Lavreotiki August 2021 Corine Land Cover 2018 over Burned Areas

Legend

CLC 2018
- Complex cultivation patterns
- Coniferous forest
- Discontinuous urban fabric
- Land principally occupied by agriculture, with significant areas of natural vegetation
- Natural grasslands
- Sclerophyllous vegetation
- Transitional woodland-shrub

<table>
<thead>
<tr>
<th>LU/LC</th>
<th>Area</th>
<th>Percentage</th>
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</thead>
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<tr>
<td>Discontinuous urban fabric</td>
<td>30</td>
<td>0,59</td>
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<tr>
<td>Complex cultivation patterns</td>
<td>420</td>
<td>8,32</td>
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<tr>
<td>Land principally occupied by agriculture, with significant areas of natural vegetation</td>
<td>660</td>
<td>13,07</td>
</tr>
<tr>
<td>Coniferous forest</td>
<td>1190</td>
<td>23,56</td>
</tr>
<tr>
<td>Natural grasslands</td>
<td>1010</td>
<td>20,00</td>
</tr>
<tr>
<td>Sclerophyllous vegetation</td>
<td>1020</td>
<td>20,20</td>
</tr>
<tr>
<td>Transitional woodland-shrub</td>
<td>720</td>
<td>14,26</td>
</tr>
</tbody>
</table>

Burned area mapping and classification according to Burn Severity.

Contains modified Sentinel-2 Copernicus data 2021.

Projection: WGS 1984 UTM Zone 34N
Pre-Event image: Sentinel-2B L2A 13/08/2021
Post-Event image: Sentinel-2B L2A 18/08/2021

August 2021
THE AUGUST 2021 WILDFIRES IN SOUTHEASTERN ATTICA (LAVREOTIKI)
EVOLUTION OF THE FIRE AND AFFECTED RESIDENTIAL AREAS

Burned areas (Copernicus EMS) along with 112 alert messages locally issued by the Hellenic General Secretary for Civil Protection. The timeline can be reached at https://arcg.is/eTeP5
THE AUGUST 2021 WILDFIRES IN WESTERN ATTICA (VILIA)
GEOLOGY OF THE FIRE-AFFECTED AREA

Legend

Quaternary
- Alluvial deposits
- Scree and talus cones

Neogene
- Marls, clays, sandstones, conglomerates, marly limestones, travertines

Sub-Pelagonian Unit
- Limestones (and locally dolomites)
- Mainly Limestones, sandstones, conglomerates, volcanic tuffs

Bauxites
- Burned area
THE AUGUST 2021 WILDFIRES IN WESTERN ATTICA (VILIA) 
EXTENT, BURN SEVERITY AND LAND COVER OF THE FIRE-AFFECTED AREA

A wildfire started on August 16 2021, in Vilia area of Western Attica.

The mapping of burned areas and their burn severity was performed with the use of two Copernicus Sentinel-2 images:

- a Pre-event image on 29/7/2021 (Sentinel-2A L2A) and
- a Post-event image on 26/08/2021 (Sentinel-2A L1C - converted to L2A)

In addition, Corine Land Cover 2018 data were utilized to identify the burned land cover types.

The burned area of about 96,000 acres is mainly characterized by moderate-high burn severity (59.04%).

According to the Corine Land Cover 2018, the burned land cover consists mostly of sclerophyllous vegetation (49.21%), coniferous forests (19.73%), and transitional woodland-shrub (17.34%).
THE AUGUST 2021 WILDFIRES IN WESTERN ATTICA (VILLA)
EXTENT OF THE FIRE-AFFECTED AREA BASED ON HIGH RESOLUTION SATELLITE IMAGES

Wildfires in Vilia, Attica 16-21 August 2021

Legend
- Settlements

Burned Areas
- 17/08/2021 → 29.67 Km²**
  (29.670 acres)
- 18/08/2021 → 66.16 Km²**
  (66.160 acres)
- 21/08/2021 → 93.22 Km²
  (93.220 acres)

** Smoke cover over the area affected significantly the mapping and its accuracy

Burned Area Progression Mapping with the use of Satellite Images from:
- ESA's Copernicus Sentinel-2 Mission
- Planet's PlanetScope Constellation

Pre-event Images:
- Sentinel-2A L2A 29/7/2021 12:05 EEST
- PlanetScope 4 band 15/8/2021 11:36 EEST

Post-event images:
- PlanetScope 4 band 17/8/2021 11:24 EEST
- Sentinel-2B L2A 18/8/2021 12:05 EEST
- Sentinel-2B L2A 21/8/2021 12:20 EEST

Projection:
- WGS 1984 UTM Zone 34N | August 2021
THE AUGUST 2021 WILDFIRES IN WESTERN ATTICA (VILLA)
EXTENT OF THE FIRE-AFFECTED AREA BASED ON HIGH RESOLUTION SATELLITE IMAGES

Wildfires in Vilia, Attica - August 2021

Legend
- Settlements

Burned Areas
- 17/08/2021 → 29.67 Km²**
- 18/08/2021 → 66.16 Km²**
- 21/08/2021 → 93.22 Km²
- 26/08/2021 → 95.98 Km²

** Smoke cover over the area affected significantly the mapping and its accuracy

Burned Area Progression Mapping with the use of Satellite Images from:
ESA’s Copernicus Sentinel-2 Mission
Planet’s PlanetScope Constellation

Pre-event Images:
Sentinel-2A L2A 29/7/2021 12:05 EEST
PlanetScope 4 band 15/8/2021 11:36 EEST

Post-event Images:
PlanetScope 4 band 17/8/2021 11:24 EEST
Sentinel-2B L2A 18/8/2021 12:05 EEST
Sentinel-2B L2A 21/8/2021 12:20 EEST
Sentinel-2A L1C (L2A) 26/8/2021 12:20 EEST

Projection:
WGS 1984 UTM Zone 34N | August 2021
THE AUGUST 2021 WILDFIRES IN WESTERN ATTICA (VILIA) BURN SEVERITY MAP

Burn Severity in Vilia, Attica - August 2021

Legend
- Settlements

Burn Severity
- 1: Low-severity
- 2: Moderate-low severity
- 3: Moderate-high severity
- 4: High-severity

Total Burned Area 26/08/2021: 95.98 Km²
THE AUGUST 2021 WILDFIRES IN WESTERN ATTICA (VILIA)
LAND COVER MAP BASED ON CORINE LAND COVER 2018

Burned Land Cover in Vilia, Attica - August 2021

Legend
- Settlements
- Land Cover
- 211: Non-irrigated arable land
- 231: Pastures
- 242: Complex cultivation patterns
- 243: Land principally occupied by agriculture, with significant areas of natural vegetation
- 312: Coniferous forest
- 313: Mixed forest
- 321: Natural grasslands
- 323: Sclerophyllous vegetation
- 324: Transitional woodland-shrub
- 333: Sparsely vegetated areas
- 334: Burnt areas

Total Burned Area 26/08/2021: 95.98 Km²
THE AUGUST 2021 WILDFIRES IN WESTERN ATTICA (VILIA)
FIRE EXTINGUISHING PROCESS

Aerial firefighting and refilling by nearby water sources
EMERGENCY RESPONSE ACTIONS
RELIEF MEASURES FOR FIRE-AFFECTED HOUSES

Measures for the relief of the fire-affected population were announced on 10 August by the Prime Minister of Greece, the Minister of Finance, the Minister of Environment and Energy and the General Secretary of Economic Policy. They mainly comprised financial assistance for:

For fire-affected houses:

- Provision of €20,000 for completely destroyed houses. €14,000 of them constitutes the advance payment for the housing assistance and the rest €6,000 is the compensation for the household goods.

- Provision of €12,000 for partially damaged and temporarily uninhabitable houses. €8,000 of them constitutes the advance payment for the housing assistance and the rest €4,000 is the compensation for the household goods.

- Provision of €5,000 for partially damaged but habitable houses. €3,000 of them constitutes the advance payment for the housing assistance and the rest €2,000 is the compensation for the household goods.

For other buildings:

- For completely destroyed buildings, advance payment of €14,000 for housing assistance.

- For severe damaged and temporarily uninhabitable buildings, advance payment of €8,000 for housing assistance.

- For severe damaged but habitable buildings, advance payment of €3,000 for housing assistance.

For fire-affected businesses:

- Provision of €8,000 to business with completely destroyed facilities.

- Provision of €4,000 to business with severely affected facilities resulting in operational disruption.

- Provision of €2,000 to business with severely affected but still operational facilities.
EMERGENCY RESPONSE ACTIONS
RELIEF MEASURES FOR FIRE-AFFECTED BUSINESSES

Immediate financial assistance has been also adopted by the involved authorities for businesses with building facilities, including farming, pig producing and poultry breeding units and agricultural holdings for fire-affected machinery, equipment, raw materials, goods, production assets and vehicles as follows:

For fire-affected businesses:

• Provision of € 8,000 to business with completely destroyed facilities
• Provision of € 4,000 to business with severely affected facilities resulting in operational disruption
• Provision of € 2,000 to business with severely affected but still operational facilities

Immediate financial assistance has been also adopted for agricultural holdings, whose facilities remained intact by the fire or they do not have facilities and have suffered damage to perennial crops, as follows:

• € 4,000 if areas of more than 50 acres have been affected.
• € 2,000 if areas between 10 and 50 acres have been affected.
• € 1,000 for smaller crops.
CIVIL PROTECTION STRENGTHENING AND RESTORATION OF NATURAL WEALTH
ADOPTED MEASURES

Medium-term measures for civil protection strengthening and for restoring the natural wealth of the country were adopted. The following reform initiatives are immediately implemented:

A. National Civil Protection Program titled “AIGIS”

It constitutes the largest civil protection upgrade program over time, which comprise supply of:

• Firefighting aircraft including helicopters and airplanes
• Transport helicopters for first responders and response teams
• Advanced vehicles for the Hellenic Fire Service and special patrol vehicles
• Floating rescue means and means for patient transport
• Folding bridges to deal with disasters induced by natural hazards
• Aerial coordination and operation centers and supply of unmanned aerial vehicles (UAV)
• Advanced fire detection and extinguishing systems
• Early warning systems for disasters induced by natural and man-made hazards
• Mechanical equipment and construction machinery

Additionally:

• 13 Regional and 64 local operation centers for Civil Protection will be set up.
B. National Reforestation Plan and implementation of Flood Protection Projects:

€ 224 m have been earmarked from the Recovery Fund for the reforestation of 165,000 acres. The project aims not only at the restoration of burned areas but also at the qualitative differentiation of the new reforested areas, with new varieties, more resistant to summer fires.

In addition, € 110 million has been earmarked from the Recovery Fund for multi-purpose investments aiming at reducing flood risks, providing water for irrigation purposes in areas with high drought during the summer season and enhancing effective water management in selected areas in Greece.

Furthermore, another € 100 million has been earmarked from the Recovery Fund for biodiversity protection actions.

At the same time, additional actions for biodiversity are being launched through the National Strategic Reference Framework, amounting to 1.5 billion euros, which include reforestation among others.

C. Issuing of green bond

The Ministry of Finance started an investigation, since early June, to create a framework for the issuance of Greek government bonds, the credit income of which will be used for projects, actions and programs of the State with an exclusive orientation to green and sustainable economic development. According to the plan, the first issue of such a medium-term government title will be part of the public publishing strategy for next year.
Wildfire Stressors

The recent wildfires and evacuation orders have affected many individuals and communities. Besides the temporary relocation of thousands, individuals experienced secondary fire effects even miles away, for days.

Furthermore, given the scale of most incidents and extensive media coverage, even individuals (including children) living far away were emotionally affected.

Evacuation Experiences

Evacuation itself is an emotionally charged process. In some cases, communities may have hours to evacuate, others will only have a short time available to follow official directions. Even in cases where evacuation was not necessary, anticipating the event can be an emotionally stressful experience.

Aftermath

Even though wildfires only last for a certain amount of time, individuals and communities may be involved in the effects it has caused for months or even years. After a fire, residents return to their community in a devastated landscape. Thus, in addition to economic and social stressors, home and community rebuilding concerns, and health concerns, residents also face a ubiquitous environmental reminder of the event.
Impact of Fires on Mental Health
Individual Reactions

Introduction

Human reactions to wildfires are diverse and generally depend on the interplay of three key factors: disaster, community, and individual characteristics.

Furthermore, they will depend on pre-existing circumstances and stressors, factors directly related to the disaster and relevant factors of the recovery processes, both on the individual and community level.

Mental and emotional phenomena

Individuals may exhibit a variety of reactions, or consecutively different reactions or even non-typical reactions. Moreover, delayed emotional responses to the events are possible. Mental and emotional phenomena that may be observed include:

- Emotional numbness
- Hyperarousal
- Pervasive Stress
- Survivor guilt
- Ambivalence towards helpers
- Cognitive and emotional imbalance

From Aten et al. (2015)
# IMPACT OF FIRES ON MENTAL HEALTH
## POSSIBLE AND COMMON SYMPTOMS

<table>
<thead>
<tr>
<th>Common Reactions to Unexpected Events</th>
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<table>
<thead>
<tr>
<th>Physical Symptoms</th>
<th>Cognitive Symptoms</th>
<th>Emotional Symptoms</th>
<th>Behavioral Symptoms</th>
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</thead>
<tbody>
<tr>
<td>• Fatigue</td>
<td>• Memory loss</td>
<td>• Memory loss</td>
<td>• Insomnia</td>
</tr>
<tr>
<td>• Shock symptoms</td>
<td>• Concentration problems/distractibility</td>
<td>• Concentration problems/distractibility</td>
<td>• Crying easily</td>
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<tr>
<td>• Nausea</td>
<td>• Reduced attention span</td>
<td>• Reduced attention span</td>
<td>• Substance abuse</td>
</tr>
<tr>
<td>• Headaches</td>
<td>• Decision making difficulties</td>
<td>• Decision making difficulties</td>
<td>• Gallows humor</td>
</tr>
<tr>
<td>• Vomiting</td>
<td>• Calculation difficulties</td>
<td>• Calculation difficulties</td>
<td>• Gait change</td>
</tr>
<tr>
<td>• Profuse sweating</td>
<td>• Confusing trivial with major issues</td>
<td>• Confusing trivial with major issues</td>
<td>• Ritualistic behavior</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Hyper vigilance</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Unwillingness to evacuate</td>
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<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>• Fine motor tremors</td>
<td>• Decision making difficulties</td>
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<td>• Insomnia</td>
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<td>• Chills</td>
<td>• Calculation difficulties</td>
<td>• Calculation difficulties</td>
<td>• Crying easily</td>
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<td>• Teeth grinding</td>
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<td>• Substance abuse</td>
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<td>• Muscle aches</td>
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</table>
IMPACT OF FIRES ON MENTAL HEALTH
EARLY PSYCHOSOCIAL SUPPORT STRATEGIES

Normalizing Stress Reactions

It is very important to underline the fact that most reactions are to be expected in such unforeseen circumstances and will diminish with time for most individuals.

Psychoeducation in Disaster Management

Public information campaigns may be utilized in order to counteract stress, mobilize personal resources, empower individuals and foster resilience. They may be designed to provide timely and reliable information to the public regarding possible human reactions to disasters and the availability of psychosocial support services.

MSc Environmental, Disaster, and Crises Management Strategies Informational Leaflet

An informational leaflet was widely distributed online and in key points of the afflicted areas. The content included educative material regarding common human reactions to disasters and information on coping strategies and available supports. It addressed common reactions, self-care guidelines, advice on when to seek further support and useful telephone numbers.
IMPACT OF FIRES ON MENTAL HEALTH
INFORMATIONAL LEAFLET OF EDCMS
IMPACT OF FIRES ON MENTAL HEALTH
EARLY PSYCHOSOCIAL SUPPORT STRATEGIES

Mental Health First Aid

Delegations from the Psychiatric Hospital of Attica (ΨΝΑ) and the Argo Federation of Psychosocial Rehabilitation (Δίκτυο ΝΠΙΔ της Ομοσπονδίας ΑΡΓΩ), comprising of psychologists and social workers were sent to Chalkida and Aidipsos to work with and support affected individuals.

OKANA also initiated free psychosocial support for affected individuals in Attica.

NGO, volunteer and civilian actions

A great number of NGO, volunteer and civilian initiatives took place including -but not limited to- sending provisions, collecting donations, helping in reconstruction activities e.t.c

Telephone Lines for Psychological Support

The telephone line 10306 (initially used for psychological support relating to COVID-19) was expanded to offer its free services 24 hours a day to individuals affected by the fires.

The free telephone line 1110 was also activated to offer similar support.
Nitrogen dioxide (NO₂) and nitrogen oxide (NO) together are usually referred to as nitrogen oxides (NOₓ = NO + NO₂). They are important trace gases in the Earth’s atmosphere, present in both the troposphere and the stratosphere.

They enter the atmosphere as a result of anthropogenic activities (notably fossil fuel combustion and biomass burning) and natural processes such as wildfires. During daytime, i.e. in the presence of sunlight, a photochemical cycle involving ozone (O₃) converts NO into NO₂ on a timescale of minutes, so that NO₂ is a robust measure for concentrations of nitrogen oxides.

The data are processed from Level-2 to Level-3 (regrided, quality filtered) and visualized in order to monitor the spatial distribution of air pollution caused by wildfires. The processing of Sentinel-5p data was carried out using Python and visualized through panoply software.
NO₂ EMISSIONS DETECTED BY SENTINEL-5P SATELLITE MISSION

04/08/2021

05/08/2021

06/08/2021

07/08/2021

NO₂ 10⁻¹⁵ (molecules/cm²)

0,0  2,0  4,0  6,0  8,0  10,0
NO\textsubscript{2} EMISSIONS DETECTED BY SENTINEL-5P SATELLITE MISSION

08/08/2021

10/08/2021

09/08/2021

\textbf{NO2 10^15 (molecules/cm^2)}
Wildfires expose populations to a variety of environmental hazards, ranging from combustion caused by the fire itself to air pollution from smoke and combustion byproducts such as ash. Furthermore, when wildfires spread into communities, chemicals found in plastics and other materials can be released into the air from burning structures and furnishings.

Wildfire smoke can contain carbon monoxide, benzene, formaldehyde, particulate matter (PM), acrolein, and polycyclic aromatic hydrocarbons (PAHs).

- **Carbon monoxide (CO)** is a colorless, odorless gas produced by incomplete combustion of wood or other organic materials. CO dilutes rapidly so is rarely a concern for the general public, or people with heart disease who are at-greater risk from exposure, unless they are in very close proximity to the wildfire (generally within three miles of the fire line and when smoldering fuels are present). CO can be a concern to firefighters close to the fire line. CO enters the bloodstream through the lungs and reduces oxygen delivery to the body’s organs and tissues. People with cardiovascular disease may experience chest pain or cardiac arrhythmias from lower levels of carbon monoxide than healthy people. At higher levels (such as those that occur in major structural fires), carbon monoxide exposure can cause headache, weakness, dizziness, confusion, nausea, disorientation, visual impairment, coma, and death, even in otherwise healthy individuals.

- **Particulate matter** is the primary public health risk posed by short-term and long-term exposure to wildfire smoke.

- **Volatile organic compounds (VOCs)** are gases that evaporate quickly and give burning wood its characteristic smell. They can irritate the eyes, nose, throat, and lungs and their levels are higher closer to the fire.

- **Nitrogen dioxide (NO2) and sulphur dioxide (SO2)** can irritate airways, especially in people with asthma and chronic obstructive pulmonary disease (COPD).

- **Ground-level ozone** can cause reductions in lung function, inflammation of the airways, chest pain, coughing, wheezing, and shortness of breath, even in healthy people.
IMPACT OF FIRES ON PUBLIC HEALTH
PARTICULATE MATTER

Particles suspended in the air, typically as a mixture of both solid particles and liquid droplets. The size of the particles affects their potential to cause health effects.

- Particles > 10 μm in diameter do not usually reach the lungs though they can irritate the eyes, nose, and throat.
- Particles < 10 μm in diameter (PM$_{10}$) can be inhaled into the lungs and affect the lungs, heart, and blood vessels.
- Particles < 2.5 μm in diameter (PM$_{2.5}$) are the greatest risk to public health because they can reach deep into the lungs and may even make it into the bloodstream.
- Particles from smoke tend to be very small, with a size range near the wavelength of visible light (0.4–0.7 μm), and therefore efficiently scatter light and impact visibility, which can pose a serious safety risk when smoke crosses roads or impacts airports.

From https://www.encyclopedie-environnement.org/en/health/airborne-particulate-health-effects/
Particulate matter exposure can cause eye and respiratory tract irritation as well as more serious disorders such as reduced lung function, bronchitis, asthma exacerbation, heart failure, and premature death.

Short-term (days to weeks) exposure to fine particles is associated with an increased risk of premature mortality and aggravation of pre-existing respiratory and cardiovascular disease.

Furthermore, exposure to high concentrations of fine particles can cause persistent cough, phlegm, wheezing, and difficulty breathing.

Exposures to fine particles can also affect healthy people, causing respiratory symptoms, transient reductions in lung function, and pulmonary inflammation.

Particulate matter may also affect the body’s ability to remove inhaled foreign materials, such as pollen and bacteria, from the lungs.
Health effects attributed to wildfire smoke density or wildfire-PM range from asymptomatic subclinical biological and physiological responses affecting a large number of exposed individuals to smaller numbers demonstrating worsened clinical manifestations requiring medication use, healthcare system utilization, and even death (Cascio, 2018).

* Not everyone who is exposed to smoke from wildfires will experience health effects.

The level and duration of exposure, age, individual susceptibility, including the presence or absence of pre-existing lung (asthma, COPD) or heart disease, and other factors play significant roles in determining whether someone will experience smoke-related health problems.

From Cascio (2018)
Inhaled PM can deposit on different airway segments, some of which can enter the circulation through the air-blood barrier, resulting in oxidative stress and subsequent lung and systemic inflammation \((Wu\ et\ al.,\ 2018)\).

Apart from PM, wildfire smoke contains gases, polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs) that may also affect the cardiovascular system through inhalational route, with a contribution from dermal exposure \((Chen\ et\ al.,\ 2021)\).

Wildfire smoke can cause cardiovascular effects through three possible pathways:

- activation of autonomic reflex
- oxidative stress and systemic inflammation
- direct interaction with the vasculature
**WILDFIRE SMOKE AND COVID-19**
**KNOW THE DIFFERENCE BETWEEN SYMPTOMS FROM SMOKE EXPOSURE AND COVID-19**

- Some symptoms, like dry cough, sore throat, and difficulty breathing can be caused by both wildfire smoke exposure and COVID-19.
- Learn about symptoms of COVID-19. Symptoms like fever or chills, muscle or body aches, and diarrhea are not related to smoke exposure. If you have any of these symptoms, may need further assessment or testing for COVID-19. If you have further questions about COVID-19, contact a healthcare provider.
- If you have severe symptoms, like difficulty breathing or chest pain, immediately call 166 or the nearest emergency facility.

**Symptoms of COVID-19**

- Cough, shortness of breath or difficulty breathing
- Fever or chills
- Muscle or body aches
- Vomiting or diarrhea
- New loss of taste or smell

**People with COVID-19 are at increased risk from wildfire smoke during the pandemic.**

People who currently have or who are recovering from COVID-19 may be at increased risk of health effects from exposure to wildfire smoke due to compromised heart and/or lung function related to COVID-19.

The U.S. Air Quality Index (AQI) is a nationally uniform index promulgated by the U.S. Environmental Protection Agency (EPA) for reporting and forecasting daily air quality. It is used to report information about the most common ambient air pollutants, including those most relevant to wildfire smoke: ground-level ozone, particulate matter (PM$_{2.5}$ or PM$_{10}$), carbon monoxide, sulfur dioxide and nitrogen dioxide.

The AQI is divided into six categories. Each category corresponds to different levels of health concern and has a specific color that makes it easy for people to quickly determine whether air quality is reaching unhealthy levels in their communities. The higher the AQI value, the greater the level of air pollution and the greater the health concern.

From https://www.airnow.gov/aqi/aqi-basics/
### Air Quality Index (AQI)

**Daily AQI Color** | **Levels of Concern** | **Values of Index** | **Description of Air Quality**
--- | --- | --- | ---
Green | Good | 0 to 50 | Air quality is satisfactory, and air pollution poses little or no risk.
Yellow | Moderate | 51 to 100 | Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Orange | Unhealthy for Sensitive Groups | 101 to 150 | Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Red | Unhealthy | 151 to 200 | Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Purple | Very Unhealthy | 201 to 300 | Health alert: The risk of health effects is increased for everyone.
Maroon | Hazardous | 301 and higher | Health warning of emergency conditions: everyone is more likely to be affected.

From [https://www.airnow.gov/aqi/aqi-basics/](https://www.airnow.gov/aqi/aqi-basics/)
### Health Effects and Cautionary Messages for At Risk Populations

**For Each Air Quality Index (AQI) Category**

<table>
<thead>
<tr>
<th>AQI Category (AQI Values)</th>
<th>Health Effects</th>
<th>Cautionary Statements</th>
<th>Other Protection Messages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Good</strong> (0-50)</td>
<td>None expected</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>Moderate</strong> (51-100)</td>
<td>• Possible aggravation of heart or lung disease</td>
<td>• Unusually sensitive individuals should consider limiting prolonged or heavy exertion. • People with heart or lung disease should pay attention to symptoms. • Individuals with symptoms of lung or heart disease, including repeated coughing, shortness of breath or difficulty breathing, wheezing, chest tightness or pain, palpitations, nausea, unusual fatigue or lightheadedness, should contact a health care provider.</td>
<td>• If symptomatic, reduce exposure to particles by following advice in box below</td>
</tr>
</tbody>
</table>

From “Wildfire Smoke: A guide for public health officials” (EPA-452/R-19-901, August 2019)  
<table>
<thead>
<tr>
<th>AQI Category (AQI Values)</th>
<th>Health Effects</th>
<th>Cautionary Statements</th>
<th>Other Protection Messages</th>
</tr>
</thead>
</table>
| Unhealthy for Sensitive Groups (101-150) | • Increasing likelihood of respiratory or cardiac symptoms in sensitive individuals, aggravation of heart or lung disease, and premature mortality in people with heart or lung disease and older adults. | • Sensitive Groups: People with heart or lung disease, the elderly, children, and pregnant women should limit prolonged or heavy exertion.  
• Limit time spent outdoors.  
• Avoid physical exertion.  
• People with asthma should follow their asthma management plan.  
• Individuals with symptoms of lung or heart disease that may be related to excess smoke exposure, including repeated coughing, shortness of breath or difficulty breathing, wheezing, chest tightness or pain, heart palpitations, nausea, unusual fatigue or lightheadedness, should contact a health care provider. | • Keep doors and windows closed, seal large gaps as much as possible.  
• Avoid using exhaust fans (e.g., kitchen, bathroom, clothes dryer, and utility room exhaust fans).  
• Keep the garage-to-home door closed.  
• If cooling is needed, turn air conditioning to re-circulate mode in home and car, or use ceiling fans or portable fans (but do not use whole house fans that suck outdoor air into the home).  
• If a home has a central heating and/or air conditioning system, install higher-efficiency filters (e.g., filters rated at MERV 13 or higher) if they can be accommodated by the system. Regardless of whether a filter upgrade has been performed, the system’s circulating fan can be temporarily set to operate continuously to obtain maximum particle removal by the central air system’s filter, although this will increase energy use and costs.  
• Operate appropriately sized portable air cleaners to reduce indoor particle levels.  
• Avoid indoor sources of pollutants, including tobacco smoke, heating with wood stoves and kerosene heaters, frying or broiling foods, burning candles or incense, vacuuming, and using paints, solvents, cleaning products, and adhesives.  
• Keep at least a 5-day supply of medication available.  
• Have a supply of non-perishable groceries that do not require cooking. |

## HEALTH EFFECTS AND CAUTIONARY MESSAGES FOR AT RISK POPULATIONS
FOR EACH AIR QUALITY INDEX (AQI) CATEGORY

<table>
<thead>
<tr>
<th>AQI Category (AQI Values)</th>
<th>Health Effects</th>
<th>Cautionary Statements</th>
<th>Other Protection Messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unhealthy (151–200)</td>
<td>• Increased aggravation of heart or lung disease and premature mortality in persons with heart or lung disease and older adults; increased respiratory effects in general population.</td>
<td>• Sensitive Groups: Should avoid prolonged or heavy exertion</td>
<td>• Sensitive Groups: Stay in a “clean room” at home (where there are no indoor smoke or particle sources, and use a non-ozone producing air cleaner).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Everyone: Should limit prolonged or heavy exertion</td>
<td>• Go to a “cleaner air” shelter or possibly out of area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Limit time spent outdoors.</td>
<td>• Everyone: Follow advice for sensitive groups in box above.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Individuals with symptoms of lung or heart disease that may be related to excess smoke exposure, including repeated coughing, shortness of breath or difficulty breathing, wheezing, chest tightness or pain, palpitations, nausea or unusual fatigue or lightheadedness, should contact your health care provider.</td>
<td>• Identify potential “cleaner air” shelters in the community.</td>
</tr>
</tbody>
</table>

From “Wildfire Smoke: A guide for public health officials” (EPA-452/R-19-901, August 2019)
### HEALTH EFFECTS AND CAUTIONARY MESSAGES FOR AT RISK POPULATIONS
FOR EACH AIR QUALITY INDEX (AQI) CATEGORY

<table>
<thead>
<tr>
<th>AQI Category (AQI Values)</th>
<th>Health Effects</th>
<th>Cautionary Statements</th>
<th>Other Protection Messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Unhealthy (201-300)</td>
<td>• Significant aggravation of heart or lung disease, premature mortality in persons with heart or lung disease and older adults; significant increase in respiratory effects in general population.</td>
<td>• Everyone: Should avoid prolonged or heavy exertion and stay indoors, preferably in a space with filtered air.</td>
<td>• Everyone: If symptomatic, seek medical attention. If you are unable to create your own cleaner indoor air space to shelter in place, evacuate to a cleaner air shelter or leave the area, if it is safe to do so.</td>
</tr>
</tbody>
</table>

HEALTH EFFECTS AND CAUTIONARY MESSAGES FOR AT RISK POPULATIONS
FOR EACH AIR QUALITY INDEX (AQI) CATEGORY

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</tr>
</thead>
<tbody>
<tr>
<td>Hazardous (&gt; 300)</td>
<td>• Serious aggravation of heart or lung disease, premature mortality in persons with heart or lung disease and older adults; serious risk of respiratory effects in general population.</td>
<td>• Everyone: Should avoid any outdoor activity, and stay indoors, preferably in a space with filtered air.</td>
<td>• Everyone: If symptomatic, seek medical attention. If you are unable to create your own cleaner indoor air space to shelter in place, evacuate to a cleaner air shelter or leave the area, if it is safe to do so.</td>
</tr>
</tbody>
</table>

From “Wildfire Smoke: A guide for public health officials” (EPA-452/R-19-901, August 2019)
### SPECIFIC STRATEGIES TO REDUCE EXPOSURE TO WILDFIRE SMOKE

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stay indoors</strong></td>
<td>Staying inside with the doors and windows closed can reduce the entry of outdoor air into homes by a third or more.</td>
</tr>
<tr>
<td><strong>Reduce activity</strong></td>
<td>Reducing physical activity lowers the dose of inhaled air pollutants and reduces health risks during a smoke event. When exercising, people can increase their air intake 10 to 20 times over their resting level. People tend to breathe through their mouths during exercise, bypassing the natural filtering ability of the nasal passages.</td>
</tr>
<tr>
<td><strong>Reduce other sources of indoor air pollution</strong></td>
<td>Indoor sources of air pollution (smoking cigarettes, using gas or wood-burning stoves and furnaces, spraying aerosol products, frying and broiling meat, burning candles and incense, and vacuuming) can increase indoor particle levels.</td>
</tr>
</tbody>
</table>
| **Use air conditioners and filters**          | • Homes with central air conditioners generally have lower concentrations of particles from the outdoors compared to homes that use open windows for ventilation. Most air conditioners are designed by default to recirculate indoor air. Those systems that have both “outdoor air” and “recirculate” settings need to be set on “recirculate” during smoke events.  
• Higher-efficiency filters (filters rated at MERV 13 or higher) are relatively inexpensive and preferred because they can capture more of the fine particles associated with smoke and can reduce the amount of outdoor air pollution that gets indoors (MERV: minimum efficiency reporting value). |
| **Use room air cleaners**                     | Air cleaners can help reduce indoor particle levels, provided the specific air cleaner is properly matched to the size of the indoor environment.                                                            |
| **Inside vehicles**                           | Individuals can reduce the amount of smoke in their vehicles by keeping the windows and vents closed, and operating the air conditioning in “recirculate” mode.                                             |
| **Respiratory protection for wildfire smoke and ash** | Respiratory protection can be useful for reducing personal inhalation of wildfire smoke or ash.                                                                                                           |
# At-Risk Population and Health Effects from Wildfire Smoke Exposure

<table>
<thead>
<tr>
<th>At-risk Population</th>
<th>People with asthma &amp; other respiratory diseases</th>
<th>People with cardiovascular disease</th>
<th>Children</th>
<th>Pregnant women</th>
<th>Older adults</th>
<th>People of low socioeconomic status</th>
<th>Outdoor workers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Underlying respiratory diseases → compromised health status → severe respiratory responses triggering</td>
<td>• Underlying circulatory diseases → compromised health status → severe cardiovascular events triggering</td>
<td>• Still developing children’s lungs, more time spent outdoors, engagement in more vigorous activity, and inhalation of more air per pound of body weight compared to adults → ↑ exposure to wildfire smoke</td>
<td>• Pregnancy-related physiologic changes (increased breathing rates) → ↑ vulnerability to environmental exposures.</td>
<td>• Higher prevalence of pre-existing lung and heart disease and decline of defense mechanisms.</td>
<td>• ↓ access to health care and measures to reduce exposure (air conditioning) → ↑ likelihood of untreated or insufficient treatment of underlying health conditions and ↑ levels of exposure to wildfire smoke, respectively.</td>
<td>• Extended periods of time exposed to high concentrations of wildfire smoke.</td>
</tr>
<tr>
<td></td>
<td>• Breathing difficulties (coughing, wheezing &amp; chest tightness) and chronic lung diseases (asthma &amp; COPD) exacerbations</td>
<td>• Triggering of ischemic events (angina pectoris, heart attacks &amp; stroke, worsening of heart failure or abnormal heart rhythms)</td>
<td>• In all children: coughing, wheezing, difficulty breathing, chest tightness &amp; decreased lung function</td>
<td>• Low birth weight and preterm birth (limited evidence)</td>
<td>• Exacerbation of heart and lung diseases</td>
<td>• ↑ risks of experiencing the health effects described above.</td>
<td>• ↑ risks of experiencing the range of health effects described above.</td>
</tr>
</tbody>
</table>
CREATE A CLEANER AIR SPACE

Create a Cleaner Air Space

Choose a room that fits everyone and is comfy enough to spend time in.

Close windows and doors, but do not block exits.

Filter the air. Use a certified portable air cleaner and run continuously on the highest setting.

Avoid activities that create smoke or other particles indoors.

Stay cool. Run fans or AC on recirculate with a new filter.

Use a damp cloth or mop to trap settled dust and particles.

CARB: California Air Resources Board

From https://ww2.arb.ca.gov/protecting-yourself-wildfire-smoke
RESPIRATORY PROTECTION FOR WILDFIRE SMOKE AND ASH

Well-fitted respirators offer the most effective protection from fine particulate matter (PM$_{2.5}$).

- Respirators are marked with letter and number combinations, such as N95, KN95, and KF94.
- A good fit is the most important thing for filtration of PM$_{2.5}$. Inhaled air must pass through the material of the mask, not around it.
- A well-fitted respirator will reduce PM$_{2.5}$ concentrations by more than 90%.
- A 3-layer cloth or disposable mask provides moderate protection compared with a respirator.
- The effectiveness of 3-layer masks can be improved by following the same advice used for COVID-19 protection.
- Simple 1-layer cloth masks, bandanas, gaiters, scarves, or t-shirts offer no protection, whether wet or dry.

Photos credit to California Department of Public Health
Preliminary results of erosion risk in the fire affected area using a Boolean Logic based model are depicting in these maps. The main parameters used in this preliminary stage is land use, Slope, Drainage Density, Lithology. The maps 1, 2 and 3 are presented in the following pages.
POTENTIAL POST-FIRE HAZARDS AND RISKS
EROSION RISK OF THE FIRE-AFFECTED AREAS IN WESTERN ATTICA

The erosion risk map of the Vilia fire-affected area
The erosion risk map of the Varympompi fire-affected area
POTENTIAL POST-FIRE HAZARDS AND RISKS
EROSION RISK OF THE FIRE-AFFECTED AREAS IN SOUTHEASTERN ATTICA

The erosion risk map of the Lavreotiki fire-affected area
Preliminary results of erosion risk in the fire affected area using a Boolean Logic based model. The main parameters used in this preliminary stage is land use, Slope, Drainage Density, Lithology.
POTENTIAL POST-FIRE HAZARDS AND RISKS
EROSION RISK OF THE FIRE-AFFECTED AREAS IN PELOPONNESE

Preliminary results of erosion risk in the fire affected area using a Boolean Logic based model.
The main parameters used in this preliminary stage is land use, slope, Drainage Density, Lithology.
ELSUS v2 shows levels of spatial probability of generic landslide occurrence at continental scale. It covers all European Union member states except Malta, and several neighboring countries. The map has been produced by regionalizing the study area based on elevation and climatic conditions, followed by spatial multi-criteria evaluation modelling using pan-European:

- slope angle,
- shallow sub-surface lithology, and
- land cover spatial datasets
- as the main landslide conditioning factors.

In addition:

- the location of over 149,000 landslides across Europe, provided by various national organizations or collected by the authors, has been used for model calibration and map validation.

From Wilde et al. (2014)
Thematic information used for ELSUS V2
(B) Lithology from the International hydrogeological Map of Europe (IHME)
(C) Land cover from GlobCover data set (ESA, 2010).
From Wilde et al. (2014)
In order to understand the landslide susceptibility of the fire-affected areas of July and August 2021 in Greece, we use the European Landslide Susceptibility map (ELSUS v2) implemented by Wilde et al. (2014). The boundaries of the fire-affected areas of Attica, Evia Island, Peloponnese and Rhodes Islands were provided by the Earth Observation team (HUA). Landslide susceptibility maps were prepared by S. Mavroulis (NKUA).

In addition, characteristic views of landslide susceptible sites are also presented.
According to the landslide susceptibility map for the fire-affected area of northern Attica, the susceptible areas are located at the northern part of the fire-affected area and especially north of Agia Triada area as well as in the western part of the fire-affected area, in particular along the front of the Parnitha Mt.
According to the landslide susceptibility map of Vilìa area, the majority of the fire-affected area is characterized by moderate to very high susceptibility. The central and the northern part constitute the most susceptible to landslide generation during the post-fire period.
According to the landslide susceptibility map of Lavreotiki area, the northern part of the fire-affected area is characterized mainly by high susceptibility, while the southern part by moderate susceptibility.
According to the landslide susceptibility map for the fire-affected area of northern Evia Island, the majority of the fire-affected area is characterized by high and very high landslide susceptibility. The need for an immediate multiparametric and interdisciplinary study for mitigating the adverse effects of landslides is imperative.
According to the landslide susceptibility map of the fire-affected area of the western Aegialeia, the landslide susceptibility ranges from low to high values. The area with the low susceptibility in the eastern part of the fire-affected area correspond to the deltaic area of Foinikas River. The area with the moderate to high susceptibility is located at the western part of the affected area, which is affected by active faults forming rugged morphology with steep slopes.
According to the landslide susceptibility map of the fire-affected area in the front of the western Panachaiko Mt, the landslide susceptibility ranges from moderate to high. The majority of the area is characterized by high susceptibility attributed to the rugged morphology attributed to the active fault zones in the area (Karia-Krini and Romanos fault zones).
According to the landslide susceptibility map for the fire-affected area north of Alfeios River, the majority of the area is characterized by high and to very high susceptibility. The need for an immediate multiparametric and interdisciplinary study for mitigating the adverse effects of landslides is imperative.
LANDSLIDE SUSCEPTIBILITY
SUSCEPTIBLE SITES IN GORTYNIA FIRE-AFFECTED AREA

In case of heavy rainfalls or strong earthquake ground motion, which often occur in the area, these sites have a high probability of failing and resulting in damage to adjacent infrastructures (roads, pillars) and undesirable effects on people.

The landslide susceptibility of several sites in Gortynia lies in the synergy of factors that favor triggering of slope failures, such as intense relief with steep and high slopes, the presence of non-cohesive and unconsolidated post-alpine deposits and related lithologies, similar geometry of slopes and beds and human interventions, which form instability conditions along these slopes.

Fire-affected sites close to Dafni village in Gortynia with high to very high landslide susceptibility
LANDSLIDE SUSCEPTIBILITY
SUSCEPTIBLE SITES IN GORTYNIA FIRE-AFFECTED AREA

More sites with high to very high landslide susceptibility in Gortynia (Livadaki) and Ilia (Lalas and Chelidoni areas) mainly suffered by soil slides.
According to the landslide susceptibility map for the fire-affected area of Ano Messinia – Megalopolis, the areas with high and very high susceptibility is detected in the western and the southern part of the affected area. It is mainly attributed to the intense relief of the mountainous area between the Ano Messinia and Megalopolis basins. The eastern part is characterized by very low to moderate susceptibility.
According to the landslide susceptibility map for the fire-affected area of the southwestern Messinia, the areas with high and very high susceptibility is detected in the western part of the fire-affected area and correspond to the semi-mountainous area of the Mavrovouni tectonic horst. The eastern part of very low to moderate landslide susceptibility corresponds to the lowlands of the Falathì basin.
According to the landslide susceptibility map for the fire-affected area of Laconia, the western part corresponding to the southern end of Taygetos Mt, is characterized by high to very high susceptibility.
The high landslide susceptibility is detected not only in sites composed of unstable post-alpine deposits, but also in semi-mountainous and mountainous areas suffered by the generation of rockfalls. Views from Laconia.
According to the landslide susceptibility map for the fire-affected area of Rhodes Island, the areas with high and very high susceptibility is detected in the eastern part of the fire-affected area. The western part is of very low to moderate landslide susceptibility.
POTENTIAL POST-FIRE FLOOD RISKS

The experience from previous mega-fires in Greece show clearly that floods and mass movement phenomena increase significantly for a period of many years. The frequency of flood events was tripled and of landslides/debris flows was 6 times higher in the affected area of the fire of 2007 in Peloponnese. Forest fires also affect soil structure, enhance erosion and increase runoff volumes.

<table>
<thead>
<tr>
<th>Phenomena</th>
<th>Average frequency Before the 2007 fire (events/year)</th>
<th>Average frequency After the 2007 fire (events/year)</th>
<th>Increase in the frequency of hydro-geomorphic phenomena</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floods</td>
<td>0.8</td>
<td>2.8</td>
<td>x 3.3 times</td>
</tr>
<tr>
<td>Mass movement</td>
<td>0.6</td>
<td>3.5</td>
<td>x 5.6 times</td>
</tr>
</tbody>
</table>

Source: Diakakis et al. 2017
The experience from previous mega-fires in Greece show clearly that floods and mass movement phenomena increase significantly for a period of many years. The frequency of flood events was tripled and of landslides/debris flows was 6 times higher in the affected area of the fire of 2007 in Peloponnese. Forest fires also affect soil structure, enhance erosion and increase runoff volumes.

The map on the right shows the approximate size (in sq. km) of the catchments affected by the forest fire.

Some of these catchments have a rich history of flood events, with numerous flash floods occurring in the last 30 years.
Increases in flood risk are expected to occur within the narrow floodplains of North Evia and near the coastline within small alluvial fans. Some of the locations that can be expected to experience flood phenomena are shown in red rectangles in the following map, but a detailed study of the post-fire flood risks is necessary to further understand the risks with certainty and with detail.
Increases in flood risk are expected to occur within the floodplains of Kifisos R. and to a lesser degree in the western part of the area of Marathon lake. Some of the locations that are expected to be affected by hydrogeomorphic phenomena are shown in red rectangles in the following map, but a detailed study of the post-fire flood risks is necessary to further understand the risks with certainty and with detail.

Drainage network of Attica (north part) with areas expected to be affected to a higher degree by hydrogeomorphic phenomena (left) and the burned area of the fire of Aug 2021 (right).
Increases in flood risk are expected to occur within two catchments in central Rodos island. The most affected catchment is the one on the NW side of the island (shown in the following map) hosting Theologos and other important villages. Higher-risk areas can be found in the coastal low-land areas of both catchments, both with a rich history of flood events in the last 20 years, as well as at least 6 flood-related fatalities.
Water circulation within the Aegean Sea is controlled by the prevailing wind conditions and the thermohaline circulation patterns and their seasonal variability. Winds blow mainly from the north, whilst some south-southwesterly winds blow during spring. Potential sea pollution to west coast of Evia, Gulf of Evia and possible to Andros and Skiros Island & Potential problems to sea traffic from burned trunks and other flood debris.
Deforestation, caused either by wildfires or land use changes (e.g. urbanization, pastures, new cultivation areas) leads to an amplification of erosion phenomena.

As a result, during a storm, the same water volume/time unit, is accompanied by increasingly large volumes of sediment load, thus augmenting the disaster potential of a flood.

A 10% loss of a forested area within any river basin will significantly disturb the hydrologic processes for a period of 2 years (best case scenario), or – worst case scenario – for several decades maybe even permanently.

Increased erosion phenomena, flooding and debris flows will be observed.

During the first post-fire storms, increased peak water quantities will probably occur in two “waves”. During the first “wave”, debris (ash, mud, timber) from the fire-affected areas will enhance the bank erosion potential of the rivers and challenge their volume capacity while, at the same time, the effectiveness of the various technical works will diminish, facilitating their blockage and subsequent overflow. The peak water quantity of the second “wave” will follow the river basin geomorphic features but, because of the increased sediment-load, will be significantly larger, even multiple.

As a result, all riverbeds and related technical works (drainage networks, crossings, bridges) within the fire-affected areas should be considered of impaired effectiveness and functionality and potentially dangerous during a severe storm.

Especially roads along the riverbeds and passing through narrow valleys, could potentially act as “traps” during a storm, either because of landslides and rockfalls, or because of a significant rise of the water level.

The beautiful, scenic routes of Northern Evia will probably present such a danger for some time.

Northern Evia presents an intrinsic high flooding risk. This risk is notably upgraded after the recent wildfires that affected a large percentage of its river basins.
POTENTIAL POST-FIRE HAZARDS AND RISKS
IMPARATIVE NEED FOR AN IMMEDIATE MULTIPARAMETRIC AND INTERDISCIPLINARY RESEARCH

From the abovementioned, the potential post-fire hazards comprise:

• increased soil erosion and runoff,

• increased failures along natural and road cut artificial slopes and

• greater flooding and debris flow potential during or after rainfalls and storms

It is necessary to conduct immediate multiparametric and interdisciplinary studies and research in the fire-affected areas dealing with the adverse geoenvironmental effects of the fires comprising detailed post-fire assessment of the susceptibility of the affected areas to floods, slope failures and erosion and the study on the restoration of the ecosystem.

In order to prevent these phenomena, the need to maintain the existing flood and erosion works and the implementation of new ones is considered imperative.
CONCLUSIONS

1. The forest fires of August 2021 were part of one of the most severe fire seasons of the last decades in Greece, expressed with mega-fires and multiple concurrent fires in a span of approximately 25 days.

2. Amongst the most important impacts of the fires were the damages in multiple forest ecosystems as well as hundreds of burned properties and affected socio-economic activities.

3. Amongst the many factors that hampered the battle for extinguishing the forest fires was the complex geomorphology, and the inaccessibility of parts of the landscape.

4. The fires are expected to influence to different degrees (depending on the location and severity) the hydro-geomorphic processes of the burned areas. Increased erosion and runoff rates are expected to take place, and lead to increased frequency of post-fire floods, debris flows and landslides, for a period of time that cannot be estimated but can be in the range of 2 to 15 years based on current literature.

5. Due to these post-fire phenomena parts of the road network and floodplains of the burned areas are expected to host additional risks to a high level during the winter. Especially from rock-falls, debris flows and floods in flooded roadways, ford crossings and coastal roads.

6. Parts of the burned areas have a high flood potential, with rich flood history (especially North Evia). The problem in these areas is expected to intensify.

7. Attention should be paid to debris-rich flows that could damage infrastructure and block critical cross sections of the river network (e.g. Kineta and Mandra floods). Designing or redesigning infrastructure should include these considerations.

8. It is important to carry out detailed post-fire risk mitigation studies in all burned areas with rapid assessment of risks and planning of smart structural and non-structural measures to reduce flood, landslide and other risks.
The July - August 2021 Wildfires in Greece