



National and Kapodistrian
University of Athens

Newsletter of **Environmental, Disaster, and Crises Management Strategies**

ISSN 2653-9454



Issue No.27 | July 2022



The July 19-20, 2022, Penteli (Attica, Greece) Wildfire

**E. Lekkas, S. Lozios, I. Parcharidis,
M. Diakakis, S. Mavroulis,
N.-I. Spyrou, M. Gogou, T. Falaras,
K. Vorgiopoulou, M. Vassalou,
K. Lymperopoulos, I. Aliferis,
K.-N. Katsetsiadou, E. Kotsi,
A. Berkovits, E. Stamati, S. Moraitis,
I. Zikeloglou**



About

Non-periodic publication of the Post-graduate Studies Program "Environmental Disasters & Crises Management Strategies" of the National & Kapodistrian University of Athens, issued after significant events for the immediate information of the scientific community and the general public. The publication includes also scientific data from various research teams from universities, organizations and research institutes.

Publishers:

Dr. Efthymis Lekkas
Dr. Nikolaos Voulgaris
Dr. Stylianos Lozios

Technical Editing:

Dr. Spyridon Mavroulis

Communication:

Dr. Spyridon Mavroulis (smavroulis@geol.uoa.gr)
MSc Alexia Grambas (agram@geol.uoa.gr)
MSc Katerina-Navsika Katsetsiadou (knavsika@geol.uoa.gr)

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Cited as

E. Lekkas, S. Lozios, I. Parcharidis, M. Diakakis, S. Mavroulis, N.-I. Spyrou, M. Gogou, T. Falaras, K. Vorgiopoulou, M. Vassalou, K. Lymperopoulos, I. Aliferis, K.-N. Katsetsiadou, E. Kotsi, A. Berkovits, E. Stamati, S. Moraitis, I. Zikeloglou (2022). **The July 19-20, 2022, Penteli (Attica, Greece) Wildfire**. Newsletter of Environmental, Disaster and Crises Management Strategies, 27, ISSN 2653-9454.

This study was funded by the Environmental, Disaster and Crises Management Strategies Post graduate Program of the Department of Geology and Geoenvironment of the National and Kapodistrian University of Athens.

Scientific Mission

Of the National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Department of Dynamic Tectonic Applied Geology

Contributors

NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS Department of Dynamic Tectonic Applied Geology

Prof. E. Lekkas, Assoc. Prof. S. Lozios, Dr. M. Diakakis, Dr. S. Mavroulis, PhD c. N.-I. Spyrou, PhD c. M. Gogou, PhD c. I. Aliferis, PhD c. K.-N. Katsetsiadou, PhD c. E. Kotsi, MSc A. Berkovits, PhD c. E. Stamati, MSc S. Moraitis, PhD c. I. Zikeloglou

HAROKOPIO UNIVERSITY OF ATHENS Department of Geography

Prof. I. Parcharidis, MSc T. Falaras, MSc K. Vorgiopoulou, MSc M. Vassalou, PhD c. K. Lymperopoulos



THE JULY 19-20, 2022, PENTELEI (ATTICA, GREECE) WILDFIRE

On July 19, 2022 (17:19) a wildfire broke out on Ntaou Penteli area.

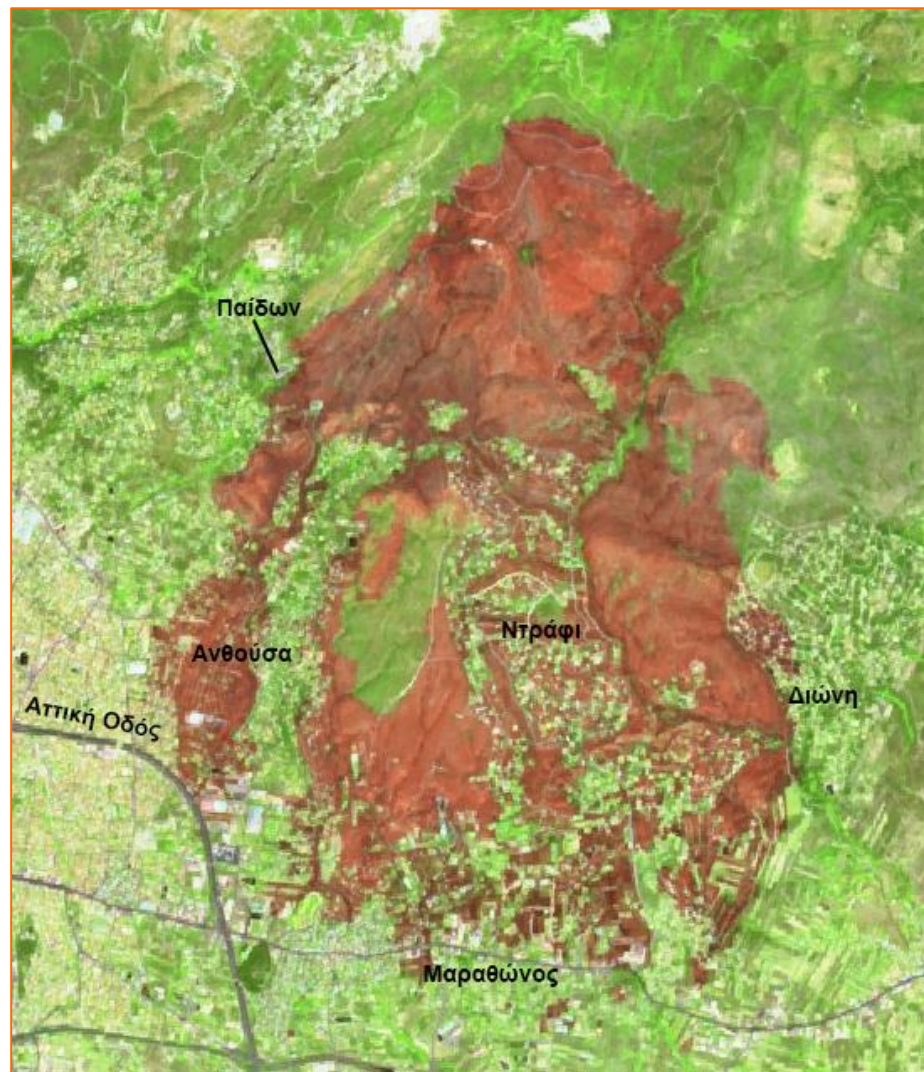
The fire moved southwards due to strong north winds, to lower altitudes towards Anthousa, Ntrafi, Dioni, Pallini towns as well as Penteli settlement to the west.

The fire burned mostly through shrub vegetation, pine trees and parts of agricultural land, leading to impacts on the environment, infrastructure and buildings.

One person committed suicide after seeing his house suffering damages from the fire.

The local population evacuated the above settlements as the fire was moving southwards and as the fire fighting forces (fire service, local authorities and volunteers) were operating in the area with land and aerial units.

The fire was extinguished in 20th of July.





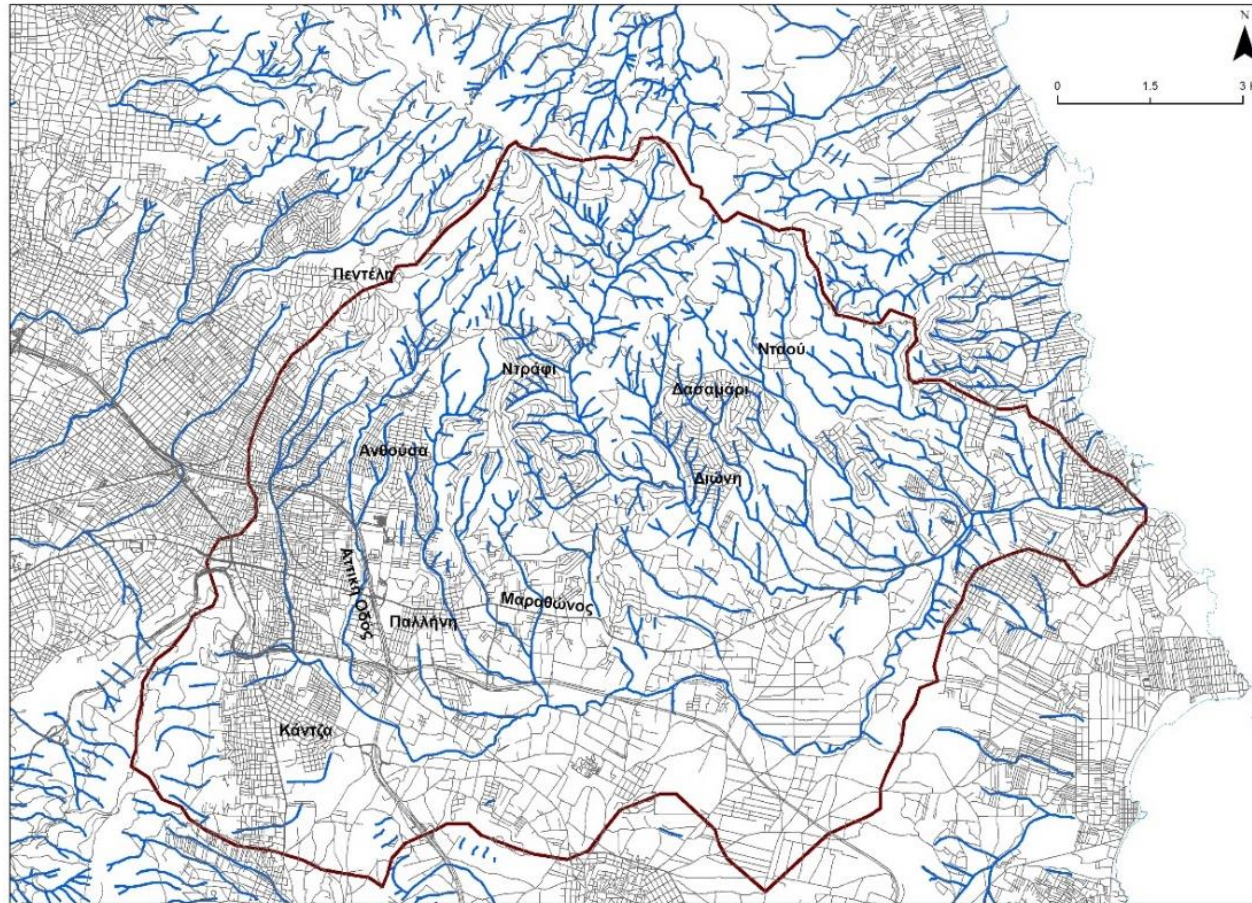
FIRE INVENTORY

Since 1981, several significant fires have been recorded on Mount Penteli. Eight of them affected part(s) of the July 2022 burned area.

Date	Burned Zones	Burned Area (ha)	Fatalities
1982	Dionysos, Penteli, Ekali, Pikermi, Gerakas, Marathonas	2500.0	2
1993	Agios Stefanos, Marathonas, Sounio, Stamata, Dionysos, Mandra, Pallini, Palea Penteli, Ntrafi	1100.0	
1995, July	Pikermi, Pallini, Ntrafi, Anthousa, Penteli, Kallitechnoupoli, Neos Voutzas	1000.0	
1998, August	Stamata, Dionysos, Rodopoli, Semeli, Anthousa, Nea Makri	9000.0	
2005, August	Rafina, Agia Triada, Agia Kyriaki, Neos Voutzas, Kallitechnoupoli	1000.0	
2007, August	Penteli, Politia, Drafi	>10000.0	
2009, August	Grammatiko, Marathonas, Pikermi, Pallini	21000.0	
2018, July	Daou Penteli, Neos Voutzas, Kokkino Limanaiki, Mati	1275.9	102



EXTENT OF THE FIRE-AFFECTED AREA



The fire burned the south and southeast slopes of Penteli Mt, affecting the catchment of Mega Rema River that drains the area.



EVOLUTION OF THE FIRE



The image illustrates the beginning of the fire at approximately 17:38, on July 19, 2022. It developed in two linear fronts. The first front headed south and south-east towards the Ntrafi community (in the right side of the image) and the second headed west towards the Old Penteli settlement. The strong wind resulted in the formation of new spot fires at long distances (Photo credit: MSc C. Karakitsakis).



EVOLUTION OF THE FIRE



Image captured the first day of the fire (July 19, 10:48 pm)
(Photo credit: Prof. E. Lekkas)



EVOLUTION OF THE FIRE



The second day of the fire (July 20, 07:40 am)
(Photo credit: Prof. E. Lekkas)



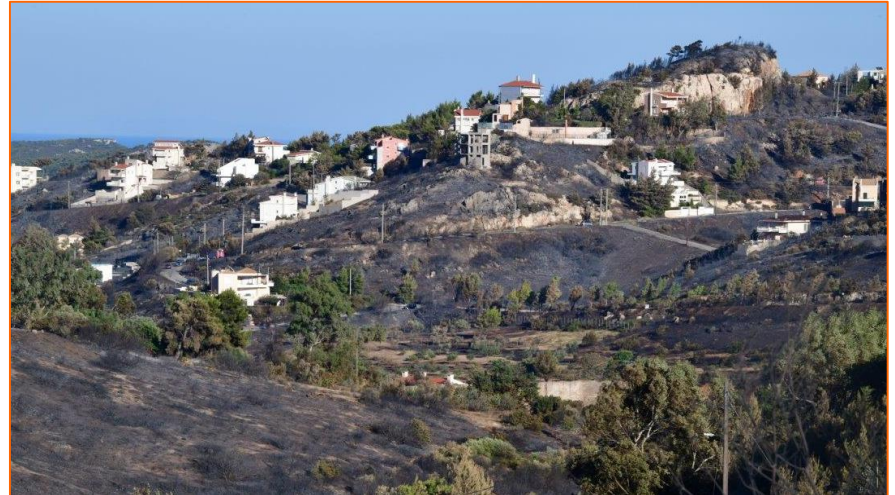
EVOLUTION OF THE FIRE



In the morning of the second day. The fire threatens houses.
(Photo credit: Prof. E. Lekkas)



EVOLUTION OF THE FIRE



The wildfire had immediate impact on the building and natural environment.
(Photo credit: Prof. E. Lekkas)



EVOLUTION OF THE FIRE



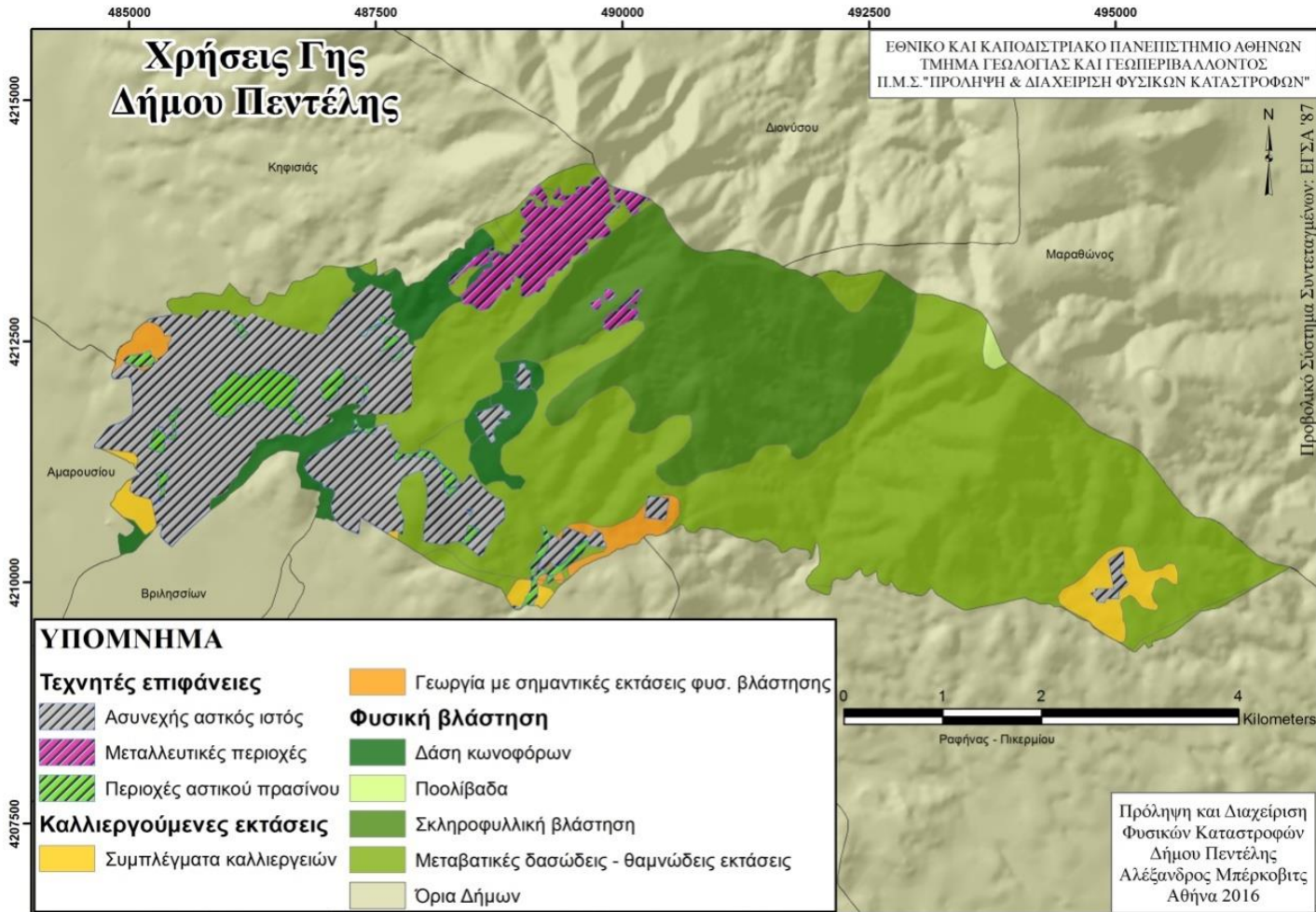
▲ ► Images captured during the second day of the fire on July 20, 2022 (Photo credit: Prof. E. Lekkas).

▲ The fire front burning at lower altitudes





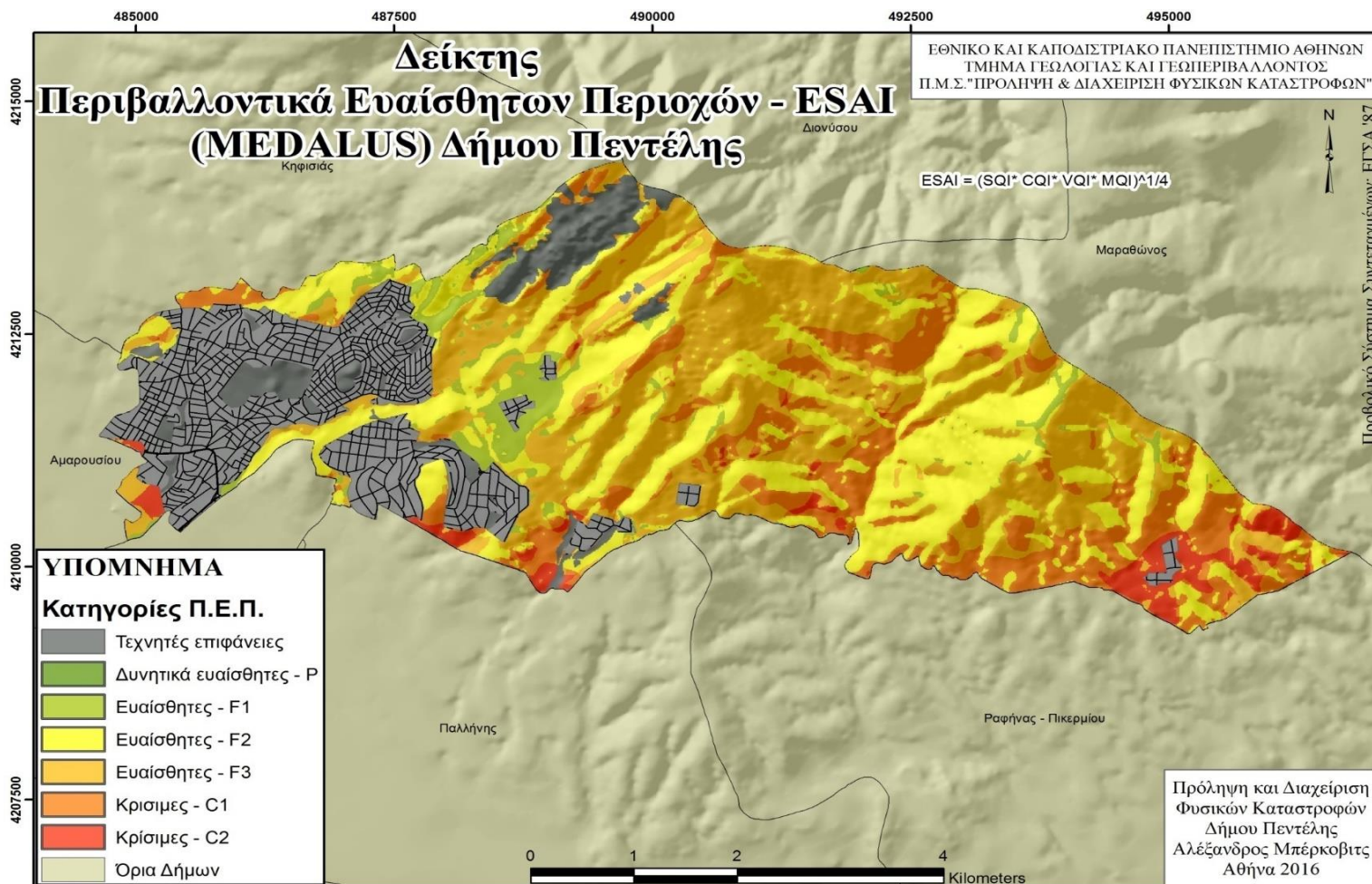
LAND COVER BASED ON CORINE 2012



Vegetation covers approximately 70% of the area. The main part of this vegetation consists of transitional forest-shrub lands and remnants of coniferous forests.



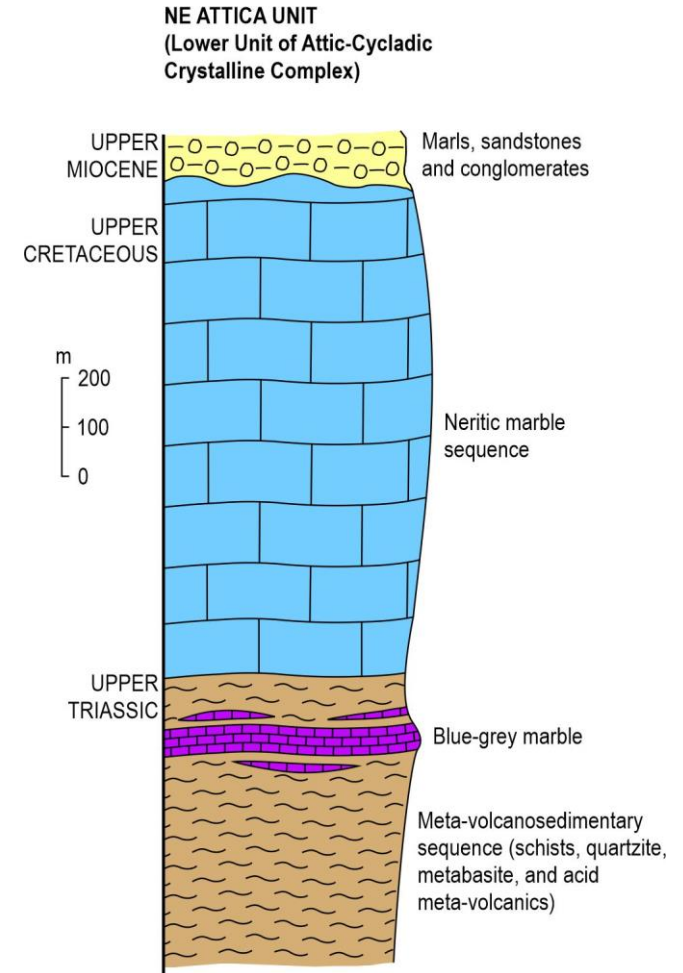
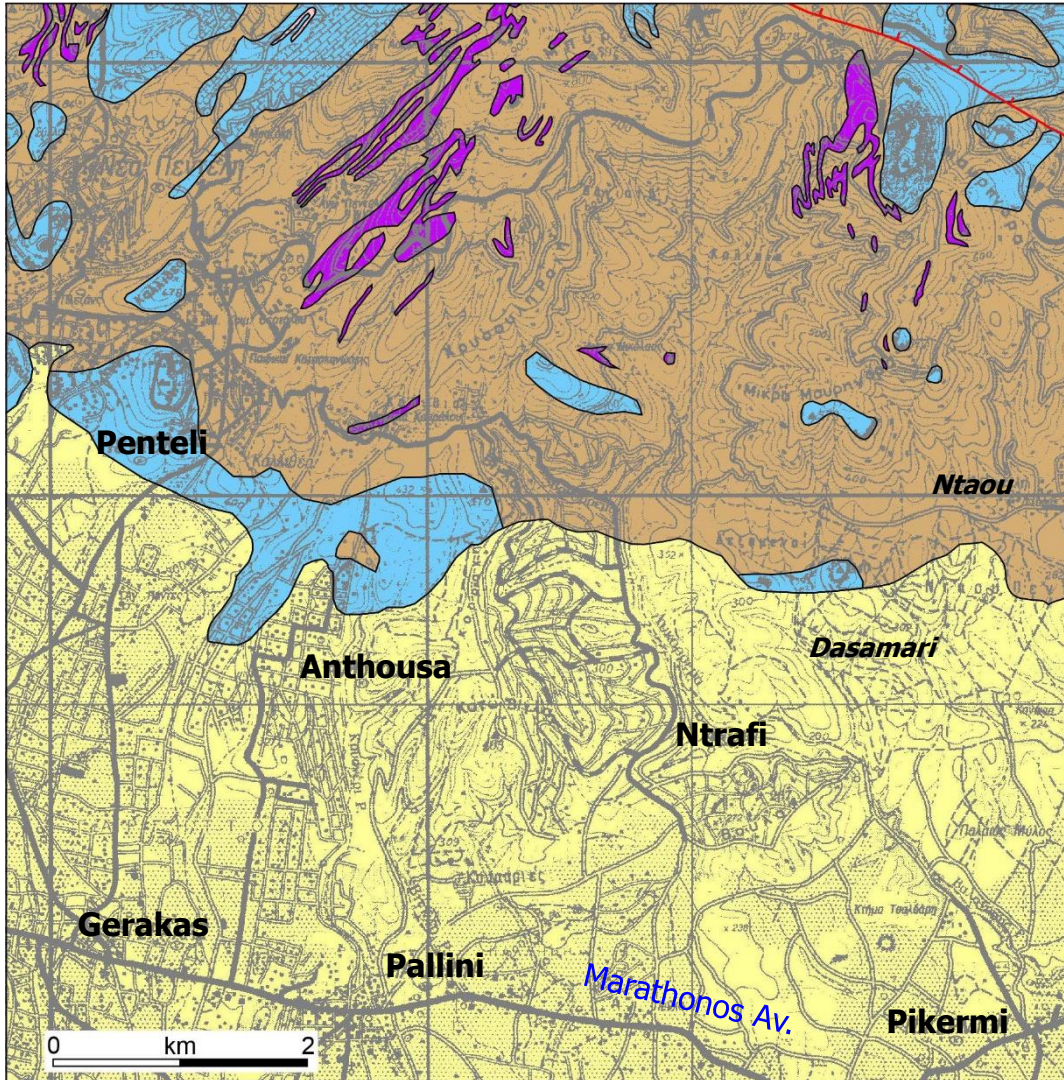
PRE-FIRE ENVIRONMENTALLY SENSITIVE AREAS



Municipality of Penteli is characterized by critical and sensitive areas, with almost 30% of the total belonging to the critical categories.



GEOLOGY OF THE FIRE-AFFECTED AREA



From *Lozios et al. (2019)*



IMPACT OF GEOLOGY ON THE FIRE EVOLUTION



Marbles

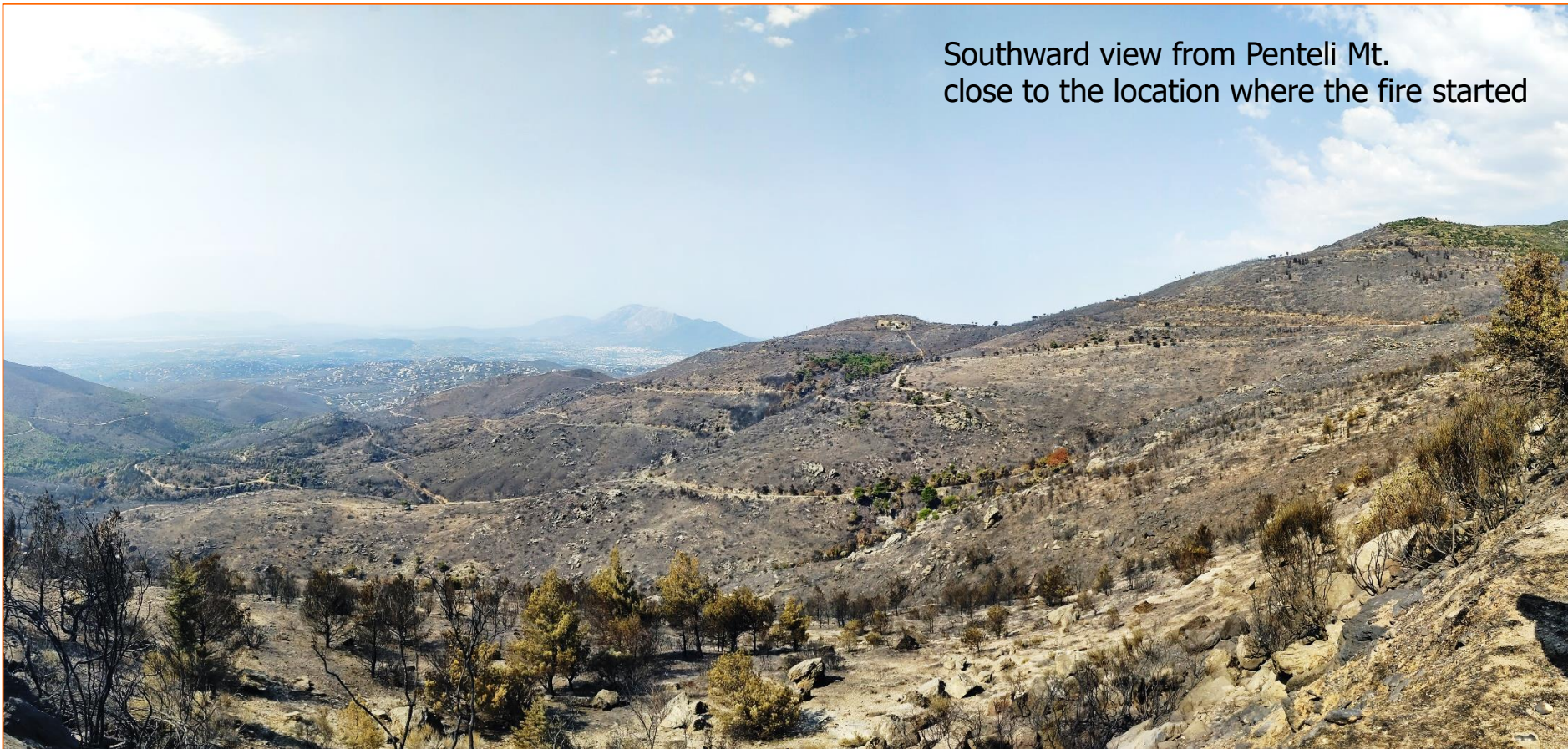
Schists

Fire limit following geological boundaries



GEOMORPHOLOGY **FIRE DETECTION AND HYDROGRAPHIC NETWORK**

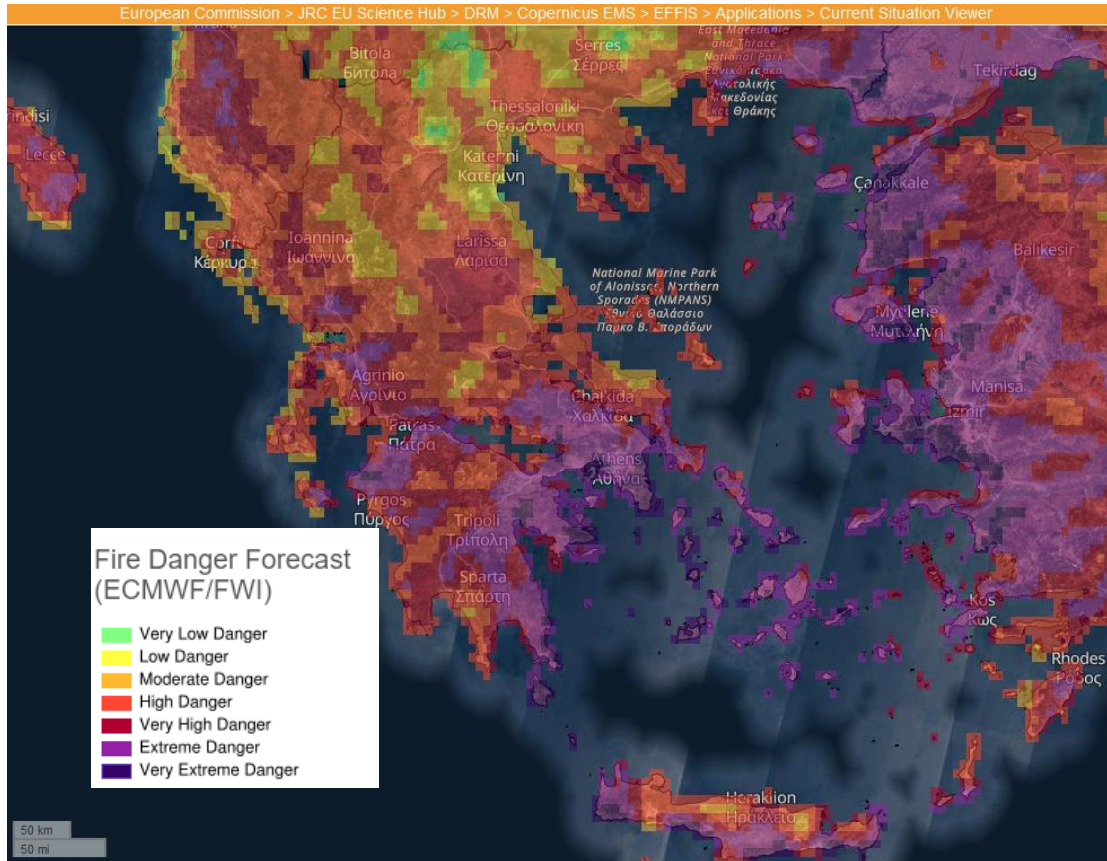
Southward view from Penteli Mt.
close to the location where the fire started



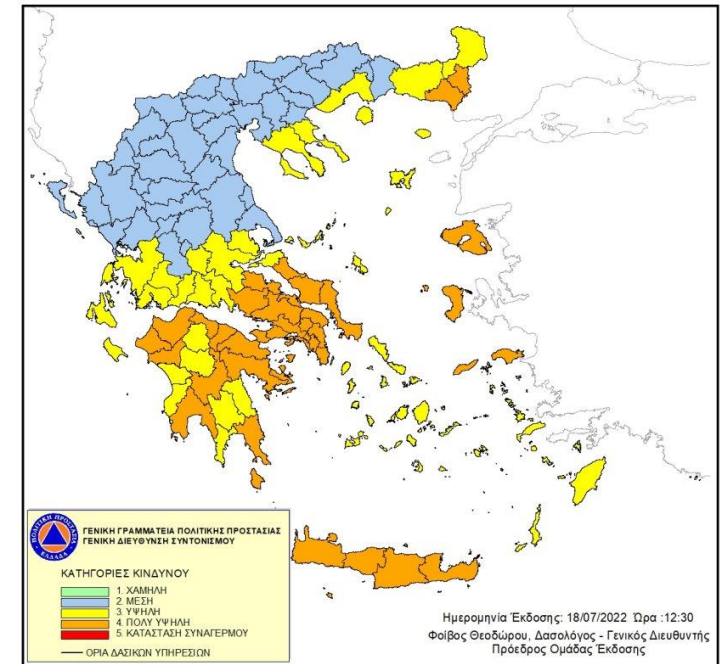
The fire moved southwards through the south and southeast slopes of Penteli (seen above) through an area of relative sharp relief reaching WUI areas at lower altitudes (far back of the photo).



FIRE DANGER FORECAST FOR ATTICA FOR 19 JULY 2022



ΧΑΡΤΗΣ ΠΡΟΒΛΕΨΗΣ ΚΙΝΔΥΝΟΥ ΠΥΡΚΑΓΙΑΣ ΠΟΥ ΙΣΧΥΕΙ ΓΙΑ Τρίτη 19/07/2022



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
https://effis.jrc.ec.europa.eu/apps/effis_current_situation/

Fire Danger Forecast map issued by the Hellenic Ministry for Climate Crisis and Civil Protection, General Secretary for Civil Protection



READINESS AND MOBILIZATION OF THE CIVIL PROTECTION AUTHORITIES TIMELINE OF ACTIONS



July 19 2022

According to the Fire Risk Prediction Map for Tuesday 19 July 2022, issued by the General Secretariat of Civil Protection of the Ministry of Climate Crisis & Civil Protection, a very high risk of fire (risk category 4) was predicted for the Attica Region as well, maintaining the risk category the same since Thursday 14-17-2022.

Based on risk category 4:

- The Hellenic Fire Service implements the 2nd stage of its operational readiness.
- Fire Departments' personnel are on partial alert.
- Patrols are conducted by Fire Service, Police and Military Forces.
- Aerial surveillance patrols are conducted.
- As a precaution measure, vehicle traffic and excursionists are prohibited to enter protected national forests, forests and vulnerable areas.

- All the competent government agencies involved, as well as the Regions and Municipalities of the country, are on high alert to take any measures needed within their competence.
- Citizens are advised to be extremely careful and avoid any activity that could cause a fire.



READINESS AND MOBILIZATION OF THE CIVIL PROTECTION AUTHORITIES TIMELINE OF ACTIONS



July 19 and 20, 2022

On the afternoon of Tuesday 19-07-2022 at 17:19, a fire broke out in low vegetation, near the Vagiati area in Penteli. Fire fighting forces were immediately mobilized in order to suppress the fire at its initial stage.

Until the afternoon of 19-07-2022 at 18:00 at least the following were involved in the fire:

- 78 firefighters with 5 teams of infantry departments, including 28 Romanian firefighters
- 22 vehicles
- 11 Aircrafts and 5 Helicopters, of which 1 Helicopter of the Greek Army, as well as 1 more Helicopter for aerial coordination
- Volunteer fire fighters
- Water tank vehicles of Regional and Local Authorities (OTA)

The Chief of the Hellenic Fire Service ordered, all the Fire Stations of Attica to be put on general alert. The Directorate for the Investigation of Arson Crimes (D.A.E.E.) was activated.

The Directorate for the Investigation of Arson Crimes (D.A.E.E.) was activated.

The fire, due to the prevailing meteorological conditions, the topography and the type of vegetation fuel, quickly took significant dimension.

Air Tractor type aircrafts which were performing their surveillance task at the time, took orders and headed directly towards the fire, finding out that their ability to intervene was reduced for reasons of flight safety, as a result of the weather conditions.



READINESS AND MOBILIZATION OF THE CIVIL PROTECTION AUTHORITIES TIMELINE OF ACTIONS



During **July 20, 2022**, the fire-fighting forces managed to bring the fire under control.

Until the evening of 20-07-2022, the following were mobilized for Penteli fire:

- 485 firefighters with 28 groups of infantry departments, including 28 Romanian firefighters.
- 120 vehicles.
- 19 Aerial Means
- The Mobile Operations Center “Olympus” of the Hellenic Fire Service.
- Unmanned Aircraft Systems of the Hellenic Fire Service.
- Volunteer fire fighters.
- Volunteers of the Civil Protection.
- Water tank vehicles and heavy construction machinery of Regional and Local Authorities (OTA).
- 22 members of the Military’s Defcalion special team.
- 626 Police officers with 232 vehicles in order ensure the safe passage of residents through the streets and protecting homes from malicious acts.
- 45 employees of the Forestry Service.
- The Special Department of Disaster Medicine.
- National Center for Emergency Assistance carrying out 30 emergency transports and 50 preventive transports of citizens.



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 Member 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 them¹. 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 threat².

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 tsunami³.

¹ <https://eena.org/document/emergency-communications-the-eu-legislative-framework/>

² <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L1972&from=EN>

³ <https://twitter.com/112Greece>





RESPONSE ACTIONS

ALERT MESSAGES FROM THE EUROPEAN EMERGENCY PHONE NUMBER 112

Tuesday 19.07

GR-Alert: Εξαιρετικά
επείγουσα ειδοποίηση

Υπουργείο Κλιματικής Κρίσης & Πολιτικής Προστασίας 19-07-2022 18:20. Αν βρίσκεστε στις περιοχές Πεντέλη, Νέα Πεντέλη, Ντράφι, Νταού Πεντέλης, Διώνη και Καλλιτεχνούπολη παραμείνετε σε ετοιμότητα και ακολουθείτε τις οδηγίες των Αρχών. Δασική πυρκαγιά στην περιοχή σας. Οδηγίες αυτοπροστασίας: <https://www.civilprotection.gr/el/dasikes-pyrkagies>
Civil Protection Greece 19-07-2022 18:20. If you are in Penteli, Nea Penteli, Ntrafi, Ntaou Pentelis, Dion and Kallitexnoupoli remain on alert and follow official guidance. Wildfire in your area. Protective action guidelines: <https://www.civilprotection.gr/en/all-guidelines#>

⚠ Ενεργοποίηση 112

📞 Αν βρίσκεστε στο #Ντράφι εκκενώστε τώρα προς #Παλλήνη

!! Δασική πυρκαγιά στην περιοχή σας

Οδηγίες αυτοπροστασίας [i bit.ly/32VyYzm](https://www.civilprotection.gr/en/all-guidelines#) (b)

⚠ Ενεργοποίηση 112

📞 Αν βρίσκεστε στην #Ανθούσα εκκενώστε τώρα προς #Γέρακα

!! Δασική πυρκαγιά στην περιοχή σας

Οδηγίες αυτοπροστασίας [i bit.ly/32VyYzm](https://www.civilprotection.gr/en/all-guidelines#) (b)

⚠ Ενεργοποίηση 112

📞 Αν βρίσκεστε στις περιοχές #Διώνη & #Δασαμάρι εκκενώστε τώρα προς #Παλλήνη

!! Δασική πυρκαγιά στην περιοχή σας

Οδηγίες αυτοπροστασίας [i bit.ly/32VyYzm](https://www.civilprotection.gr/en/all-guidelines#) (b)

18:20

18:45

19:57

20:27

(t)

⚠ Ενεργοποίηση 112

📞 Αν βρίσκεστε στις περιοχές #Παλλήνη & #Νέα Παλλήνη εκκενώστε τώρα προς #Πικέρμι #Ραφήνα

!! Δασική πυρκαγιά στην περιοχή σας

Ακολουθήστε τις οδηγίες των Αρχών

Οδηγίες αυτοπροστασίας [i bit.ly/32VyYzm](https://www.civilprotection.gr/en/all-guidelines#) (b)

⚠ Ενεργοποίηση 112

📞 Αποφύγετε τη μετακίνηση στη #Λεωφόρο_Μαραθώνος από τον κόμβο της Αττικής Οδού έως το #Πικέρμι

● Δρόμος κλειστός λόγω δασικής πυρκαγιάς στην περιοχή

Οδηγίες αυτοπροστασίας [i bit.ly/32VyYzm](https://www.civilprotection.gr/en/all-guidelines#) (c)

(b)

(c)

(t)

Wednesday 20.07

Επείγουσα ειδοποίηση τώρα
Υπουργείο Κλιματικής Κρίσης & Πολιτικής Προστασίας 20-07-2022 02:00. Αν βρίσκεστε στις περιοχές Πεντέλη και περίχ του 414 Στρατιωτικού Νοσοκομείου, εκκενώστε τώρα προς Βριλήσσια . Δασική πυρκαγιά στην περιοχή σας. Ακολουθήστε τις οδηγίες των αρχών. Οδηγίες αυτοπροστασίας: <https://www.civilprotection.gr/el/dasikes-pyrkagies>
Civil Protection Greece 20-07-2022 02:00. If you are in Penteli and around the residences of the Military Hospital 414 , evacuate now to Vrilissia . Wildfire in your area. Follow official guidance. Protective action guidelines: <https://www.civilprotection.gr/en/all-guidelines#>

(b)

02:00

Επείγουσα ειδοποίηση τώρα
Υπουργείο Κλιματικής Κρίσης & Πολιτικής Προστασίας 20-07-2022 02:50. Αν βρίσκεστε στις Ανατολικές Περιοχές του Γέρακα , εκκενώστε τώρα προς Αγία Παρασκευή . Δασική πυρκαγιά στην περιοχή σας. Ακολουθήστε τις οδηγίες των αρχών. Οδηγίες αυτοπροστασίας: <https://www.civilprotection.gr/el/dasikes-pyrkagies>
Civil Protection Greece 20-07-2022 02:50. If you are in Eastern Areas of Gerakas evacuate now to Agia Paraskevi. Wildfire in your area. Follow official guidance. Protective action guidelines: <https://www.civilprotection.gr/en/all-guidelines#>

(b)

02:50

Επείγουσα ειδοποίηση τώρα
Υπουργείο Κλιματικής Κρίσης & Πολιτικής Προστασίας 20-07-2022 04:30. Αν βρίσκεστε στη Βούλα Πικερμίου και στο Πανόραμα Παλλήνης, εκκενώστε τώρα προς Πικέρμι . Δασική πυρκαγιά στην περιοχή σας. Ακολουθήστε τις οδηγίες των αρχών. Οδηγίες αυτοπροστασίας: <https://www.civilprotection.gr/el/dasikes-pyrkagies>
Civil Protection Greece 20-07-2022 04:30. If you are in Voula Pikermiou and Panorama of Pallini , evacuate now to Pikermi. Wildfire in your area. Follow official guidance. Protective action guidelines: <https://www.civilprotection.gr/en/all-guidelines#>

(b)

04:30

05:37

06:28

112 alert messages calling near-to-fire areas (a) to evacuate to a certain direction and (b) to secure buildings from sparks. (c) to avoid using Marathonos Avenue.



PANORAMIC DRONE VIEWS OF THE FIRE-AFFECTED AREA

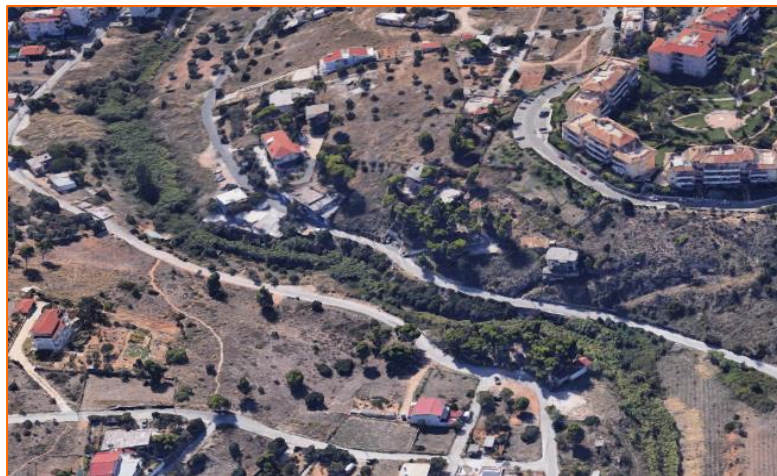




PANORAMIC DRONE VIEWS OF THE FIRE-AFFECTED AREA



Pre-fire (Google earth)



Post-fire (Drone)





DELINEATION OF BOUNDARIES OF THE FIRE-AFFECTED AREA BY USING UAV (DRONE) DATA



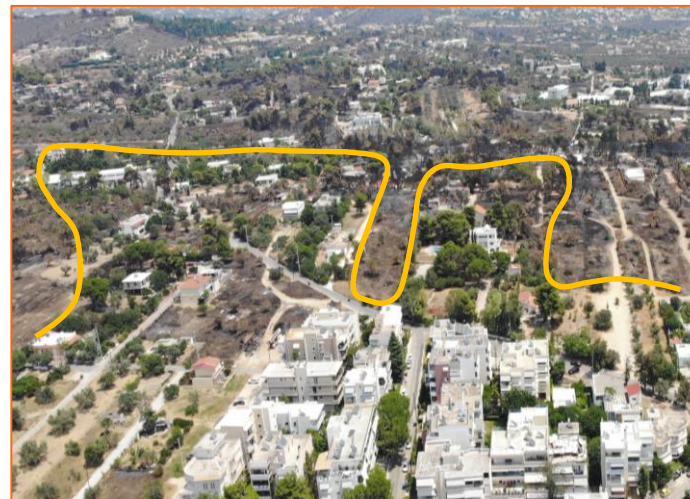
Ntrafi settlement



Dioni settlement



DELINEATION OF BOUNDARIES OF THE FIRE-AFFECTED AREA BY USING UAV (DRONE) DATA



Anthousa settlement



IMPACT ON VEGETATION DEFENSE LINES



Anthousa area

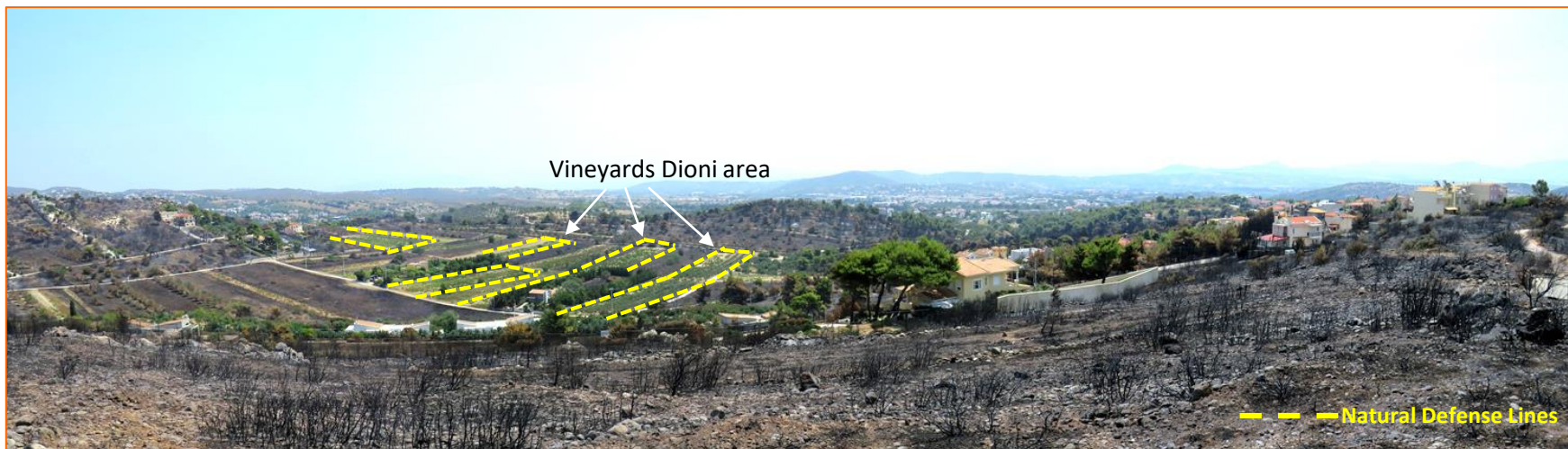


Dioni area

Vineyards with the amount of water can hold in their tissue and olive groves remained intact within the fire-affected area.



DEFENSE LINES



Vineyards with the amount of water can hold in their tissue, they become an oasis in a hot environment and a defense living plan for the wild fires.



BURNED AREA MAPPING USING SATELLITE IMAGES

For the burned area mapping, optical / multispectral NASA / USGS Landsat 9 and ESA Copernicus Sentinel-2 images were utilized for the application of the Normalized Burn Ratio based method.

- **Landsat 9 for 20/7/2022** - During the wildfire (Preliminary Burned Area)
- **Sentinel-2 for 24/7/2022** - After the wildfire (Burned Area and Burn Severity)

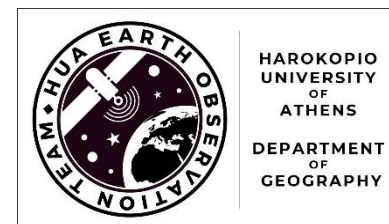
Normalized Burn Ratio (NBR) is a widely applied spectral index for the burned area mapping and burn severity assessment in remote sensing. It utilizes the **Near Infrared (NIR)** and **Shortwave Infrared (SWIR) spectral bands where burned areas show low and high reflectance accordingly**. The lower NBR values indicate burned areas (or low/no vegetation areas) while high NBR values indicate healthy vegetation.

The NBR method is calculated as:

$$NBR = \frac{(NIR - SWIR)}{(NIR + SWIR)}$$

The NBR calculation is **performed before (pre-fire) and after (post-fire)** the fire in order to estimate **their difference, the dNBR** which is used for the burned area extraction and burn severity assessment.

$$dNBR = prefireNBR - postfireNBR$$





BURNED AREA MAPPING USING SATELLITE IMAGES

The **Relativized Burn Ratio (RBR)** is an index that enables accurate Burn Severity assessment for a variety of regions and ecosystems, and it is also ideal for low vegetation cover areas. It is applied after the dNBR calculation.

$$RBR = \frac{(dNBR)}{(prefireNBR + 1.001)}$$

Burn severity is a term that expresses the degree of impact that a wildfire has on an ecosystem. It contributes to the quantification of the impact that a fire event has on an area-ecosystem, while it provides useful information for post-fire restoration and management.

Satellite imagery sources:

Landsat 9: USGS Earth Explorer

Sentinel-2: Copernicus Open Access Hub

Utilized Software:

ESA STEP SNAP v. 9.0

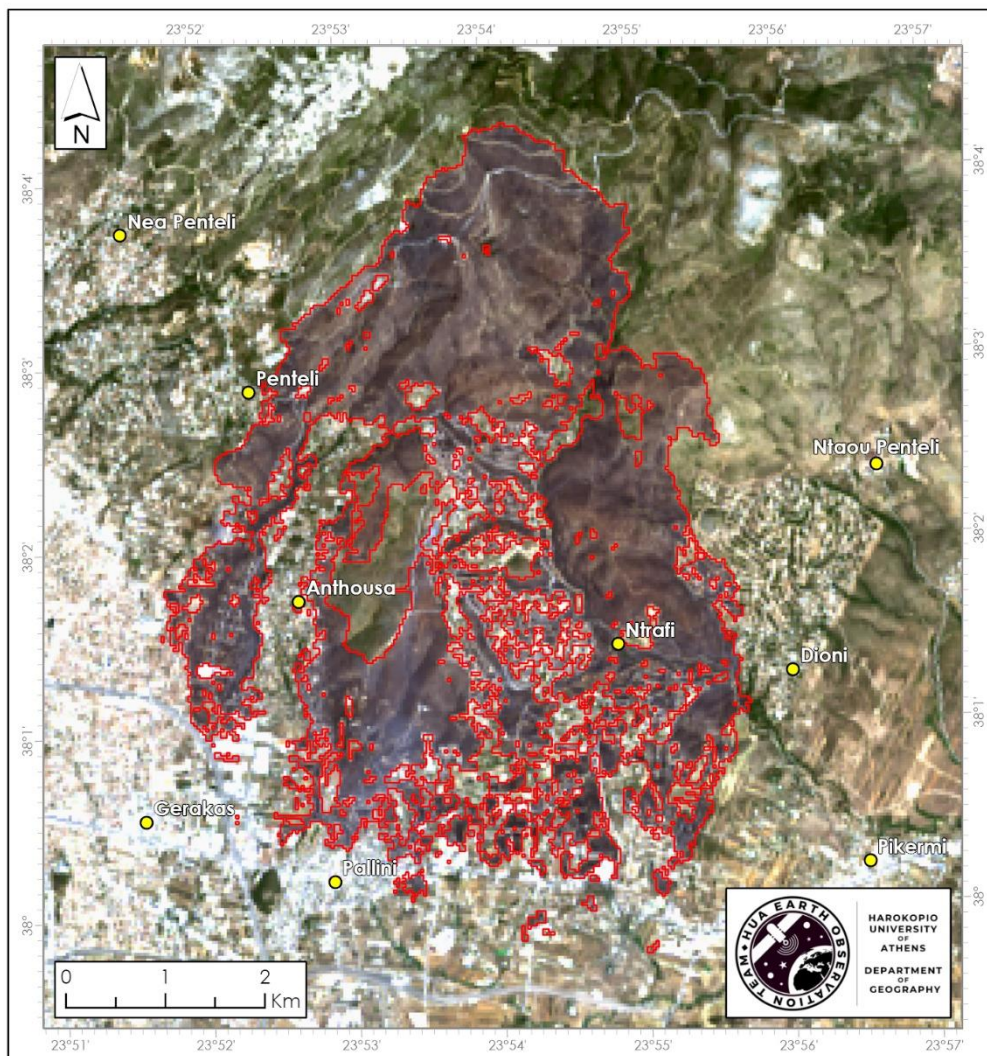
ESRI ArcGIS Pro v. 3.0, Desktop v. 10.0





BURNED AREA IN PENTELI – ATHENS SUBURBS

Burned Area as of July 20th in Penteli - Athens Suburbs (Attica)



Legend

● Settlements

□ Burned Area

Tuesday July 20th, 2022, midday Landsat 9 result:

- Burned area: **21.87 Km²**
- Resolution: 30 m X 30 m
- Images:
 - Pre-event: Landsat 9 L1TP 4/7/2022 12:04 EEST
 - Post-event: Landsat 9 L1TP 20/7/2022 12:04 EEST



Burned Area:
Calculated from the differential Normalized
Burn Ratio of pre and post event images.

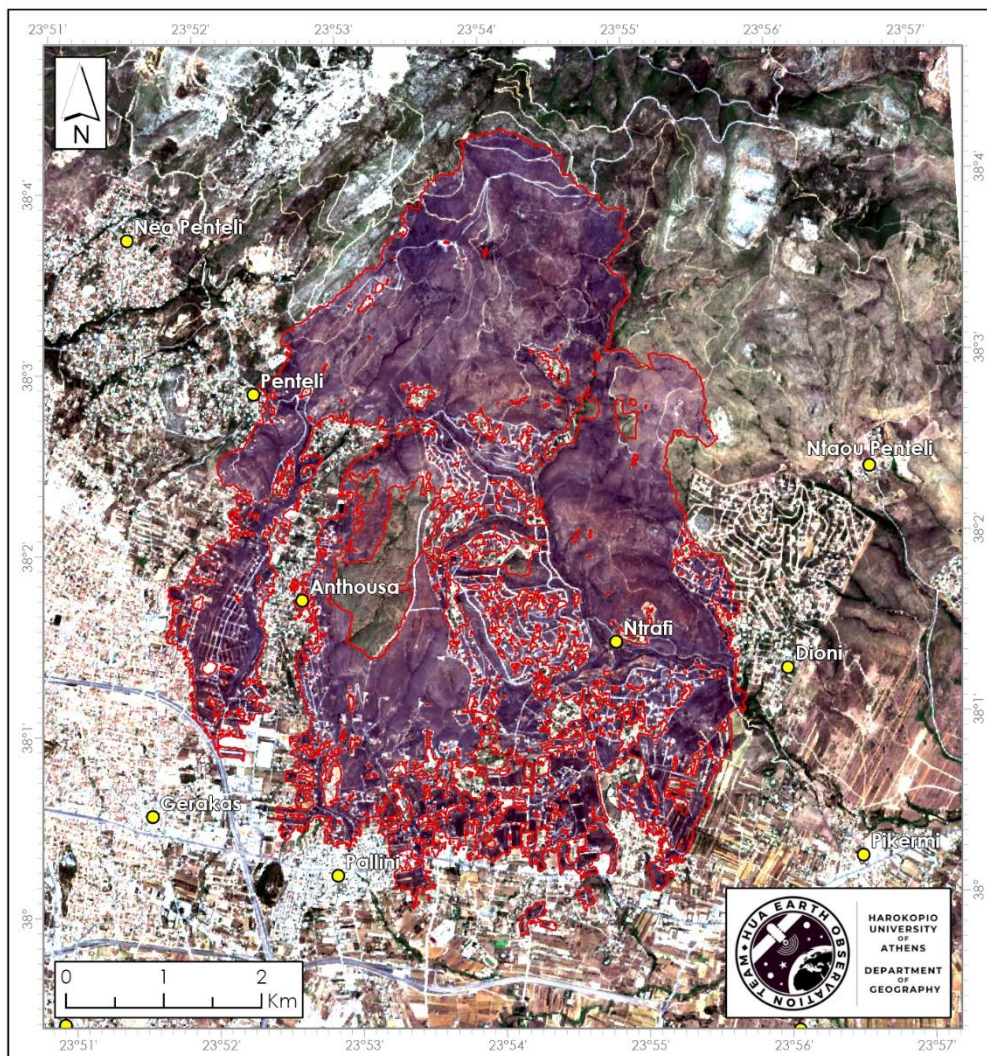
Data:
NASA/USGS Landsat Program
Landsat 9 products
Pre-event:
Landsat 9 L1TP 4/7/2022 12:04 EEST
Post-event:
Landsat 9 L1TP 20/7/2022 12:04 EEST

Projection:
WGS 1984 UTM Zone 34N | July 2022



BURNED AREA IN PENTELI – ATHENS SUBURBS

Burned Area in Penteli - Athens Suburbs (Attica) - July 2022



Legend

● Settlements

□ Burned Area

Sunday July 24th, 2022, midday Sentinel-2 result:

- Final Burned area: **24.67 Km²**
- Resolution: 10 m X 10 m
- Images:
 - Pre-event: Sentinel-2A L2A 19/7/2022 12:06
 - Post-event: Sentinel-2B L2A 24/7/2022 12:06 EEST



Burned Area:
Calculated from the differential Normalized Burn Ratio of pre and post event images.

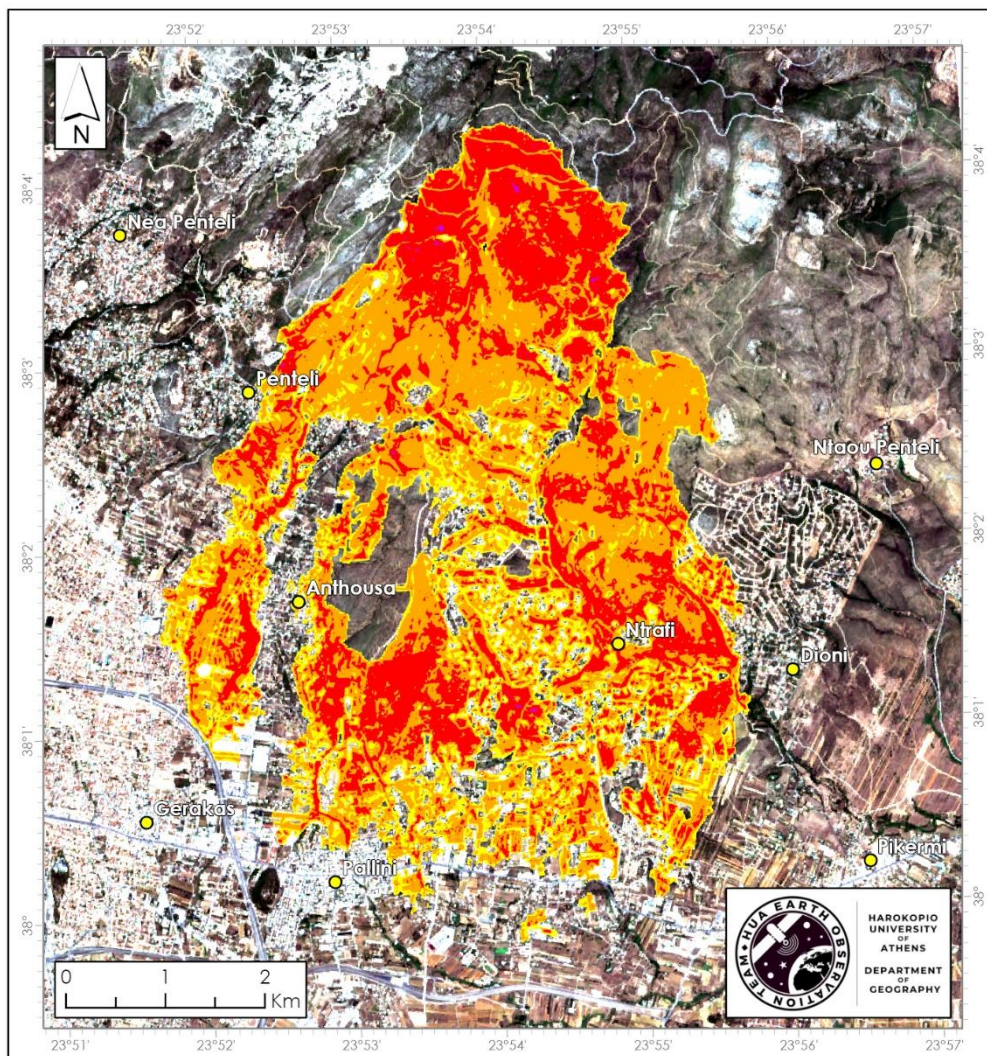
Data:
ESA's Copernicus Sentinel-2 Mission imagery
Pre-event:
Sentinel-2A L2A 19/7/2022 12:06 EEST
Post-event:
Sentinel-2B L2A 24/7/2022 12:06 EEST

Projection:
WGS 1984 UTM Zone 34N | July 2022



BURN SEVERITY AREA IN PENTELEI – ATHENS SUBURBS

Burn Severity in Penteli - Athens Suburbs (Attica) - July 2022



Legend

● Settlements

Burn Severity

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

Total Burned Area 24/7/2022: 24.67 Km²

Burn Severity	Area (Km ²)	Area Percentage (%)
Low	4.914	19.913
Moderate-low	11.334	45.928
Moderate-high	8.411	34.084
High	0.018	0.074



Burned Area - Burn Severity:
Calculated from the differential Normalized Burn Ratio of pre and post event images.

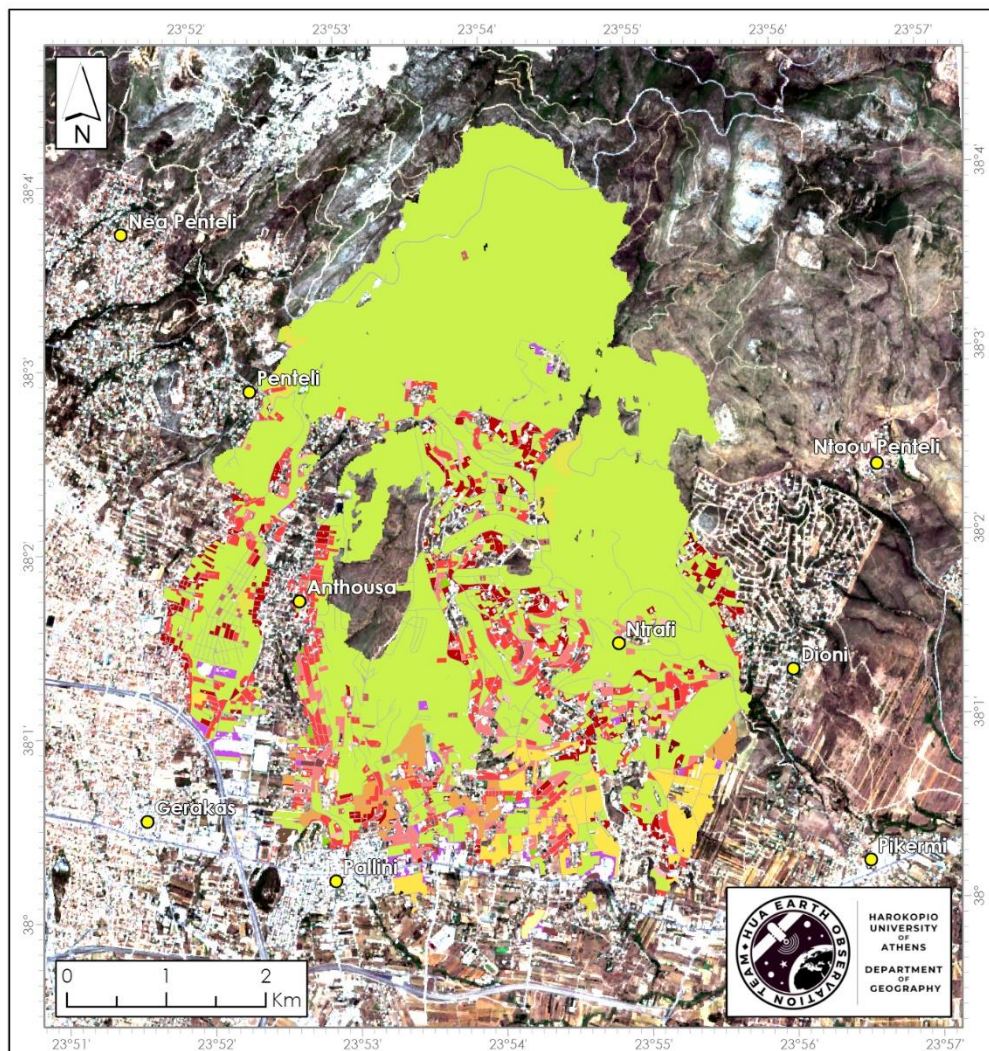
Data:
ESA's Copernicus Sentinel-2 Mission imagery
Pre-event:
Sentinel-2A L2A 19/7/2022 12:06 EEST
Post-event:
Sentinel-2B L2A 24/7/2022 12:06 EEST

Projection: WGS 1984 UTM Zone 34N | July 2022



BURNED LAND COVER ACCORDING TO URBAN ATLAS 2018

Burned Land Cover (UA 2018) in Penteli - Athens Suburbs (Attica) - July 2022



Legend

- Settlements
- Land Cover type (UA 2018)**
- 11100: Continuous Urban fabric (S.L. > 80%)
- 11210: Discontinuous Dense Urban Fabric (S.L.: 50% - 80%)
- 11220: Discontinuous Medium Density Urban Fabric (S.L.: 30% - 50%)
- 11230: Discontinuous Low Density Urban Fabric (S.L.: 10% - 30%)
- 11240: Discontinuous very low density urban fabric (S.L. < 10%)
- 11300: Isolated Structures
- 12100: Industrial, commercial, public, military and private units
- 12210: Fast transit roads and associated land
- 12220: Other roads and associated land
- 13100: Mineral extraction and dump sites
- 13400: Land without current use
- 14100: Green urban areas
- 14200: Sports and leisure facilities
- 21000: Arable land (annual crops)
- 22000: Permanent crops
- 23000: Pastures
- 24000: Complex and mixed cultivation patterns
- 32000: Herbaceous vegetation associations

UA Code	Area (Km ²)	Area Percentage (%)	UA Code	Area (Km ²)	Area Percentage (%)
11100	0.029	0.116	13100	0.025	0.100
11210	0.890	3.607	13400	0.054	0.221
11220	1.538	6.231	14100	0.041	0.165
11230	0.663	2.687	14200	0.029	0.116
11240	0.121	0.491	21000	0.032	0.130
11300	0.073	0.294	22000	0.395	1.602
12100	0.230	0.932	23000	0.252	1.023
12210	0.000	0.002	24000	0.838	3.395
12220	1.166	4.725	32000	18.302	74.165



Land Cover:
 Urban Atlas 2018 (UA 2018)
 (Copernicus Land Monitoring Service)

Images:
 ESA's Copernicus Sentinel-2 Mission imagery
 Pre-event:
 Sentinel-2A L2A 19/7/2022 12:06 EEST
 Post-event:
 Sentinel-2B L2A 24/7/2022 12:06 EEST

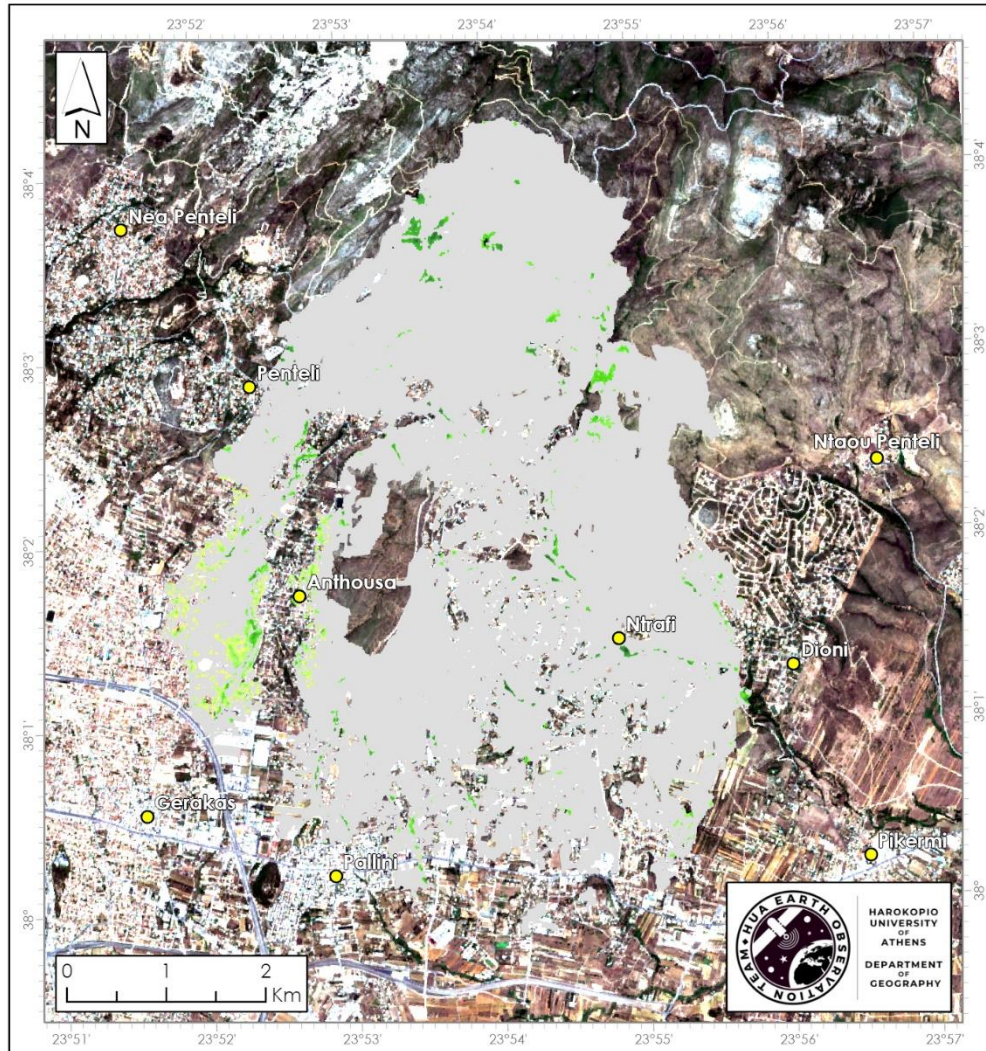
Projection:
 WGS 1984 UTM Zone 34N | July 2022





BURNED TREE COVER DENSITY IN PENTELI – ATHENS SUBURBS

Burned Tree Cover Density in Penteli - Athens Suburbs (Attica) - July 2022



Legend

- Settlements
- All non-tree covered areas
- 1-10 %
- 10-20 %
- 20-30 %
- 30-40 %
- 40-50 %
- 50-60 %
- 60-70 %
- 70-80 %
- 80-90 %
- 90-100 %
- 100 %

Tree Cover Density %	Area [Km ²]	Area Percentage (%)
All non-tree covered areas	23.765	96.306
1-10 %	0.099	0.403
10-20 %	0.155	0.629
20-30 %	0.128	0.517
30-40 %	0.109	0.442
40-50 %	0.124	0.501
50-60 %	0.106	0.429
60-70 %	0.087	0.353
70-80 %	0.066	0.268
80-90 %	0.027	0.107
90-100 %	0.009	0.036
100 %	0.002	0.008



Tree Cover Density:
 Tree Cover Density 2018
 (Copernicus Land Monitoring Service)

Images:
 ESA's Copernicus Sentinel-2 Mission imagery
 Pre-event:
 Sentinel-2A L2A 19/7/2022 12:06 EEST
 Post-event:
 Sentinel-2B L2A 24/7/2022 12:06 EEST

Projection:
 WGS 1984 UTM Zone 34N | July 2022



BURN SEVERITY, BURNED LAND COVER AND BURNED TREE COVER DENSITY RESULTS BASED ON THE PREVIOUS ANALYSIS

Burn Severity

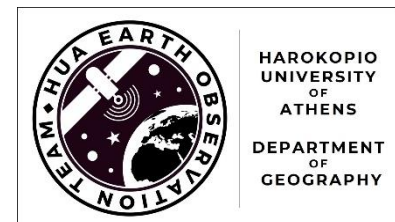
- Moderate-low severity characterizes 45.92 % or 11.33 Km² of the burned area.
- Another significant part of the area (34 %) is characterized by Moderate-high severity.

Burned Land Cover according to Urban Atlas 2018

- The wildfire affected mostly Herbaceous vegetation associations (74.16 % or 18.30 Km²).
- Important part of the affected area includes Discontinuous urban fabric.
- Urban Atlas 2018:
 - High-resolution land use-land cover for Urban Areas.
 - Minimum Mapping Width of 10 m.
 - Minimum Mapping Unit: 0.25 ha and 1 ha.
 - Source: Copernicus Land Monitoring Service.

Burned Tree Cover Density according to Tree Cover Density 2018:

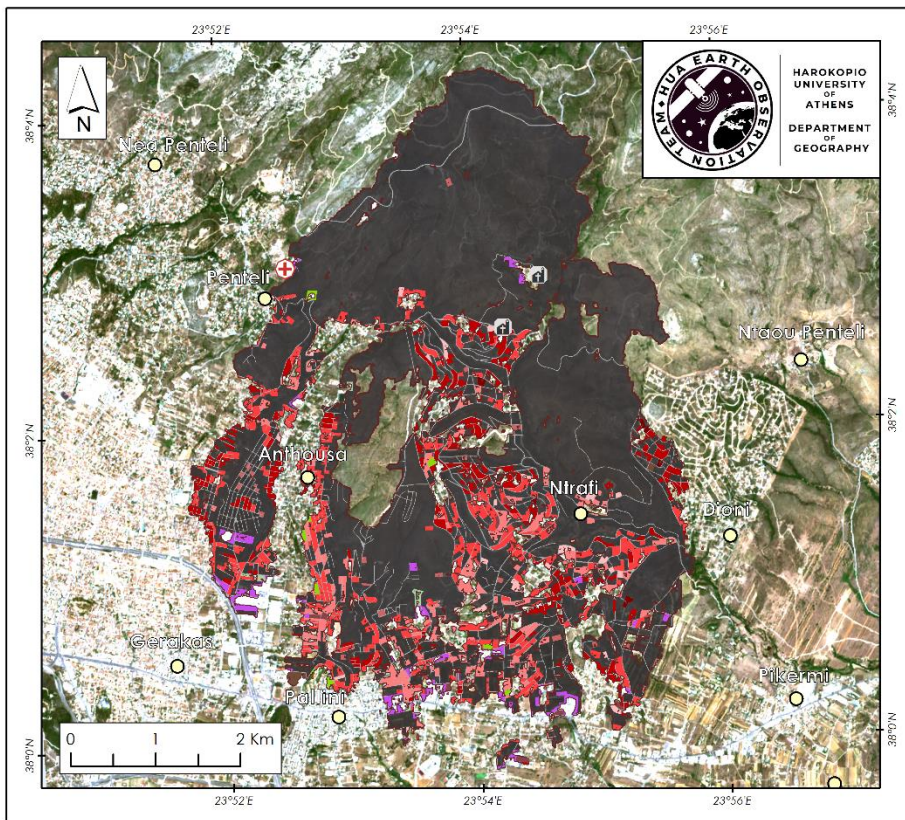
- The most affected Tree Cover Density is between 10 to 20 %.
- Other affected concentrations include 20-30 % and 40-50 %.
- Tree Cover Density 2018:
 - High-resolution Forest 2018 dataset.
 - Spatial resolution: 10 m.
 - Source: Copernicus Land Monitoring Service.





INFRASTRUCTURE EXPOSURE IN PENTELI FIRE-AFFECTED AREA

Infrastructure Exposure in Penteli, Athens Suburbs (Attica) - July 2022



Legend

- Settlements
- Hospital (Neighboring to burned area)
- Church
- Burned Area

Urban Atlas 2018 - Infrastructures

- 11100: Continuous Urban fabric
- 11210: Discontinuous Dense Urban Fabric
- 11220: Discontinuous Medium Density Urban Fabric
- 11230: Discontinuous Low Density Urban Fabric
- 11240: Discontinuous very low density urban fabric
- 11300: Isolated Structures
- 12100: Industrial, commercial, public, military and private units
- 12210: Fast transit roads and associated land
- 12220: Other roads and associated land
- 13100: Mineral extraction and dump sites
- 13400: Land without current use
- 14100: Green urban areas
- 14200: Sports and leisure facilities



Infrastructure Exposure Mapping
 Urban Atlas 2018
 (Copernicus Land Monitoring Service)

Background image:
 Satellite Image of Copernicus
 Sentinel - 2B L2A 24/07/2022 12:06 EEST

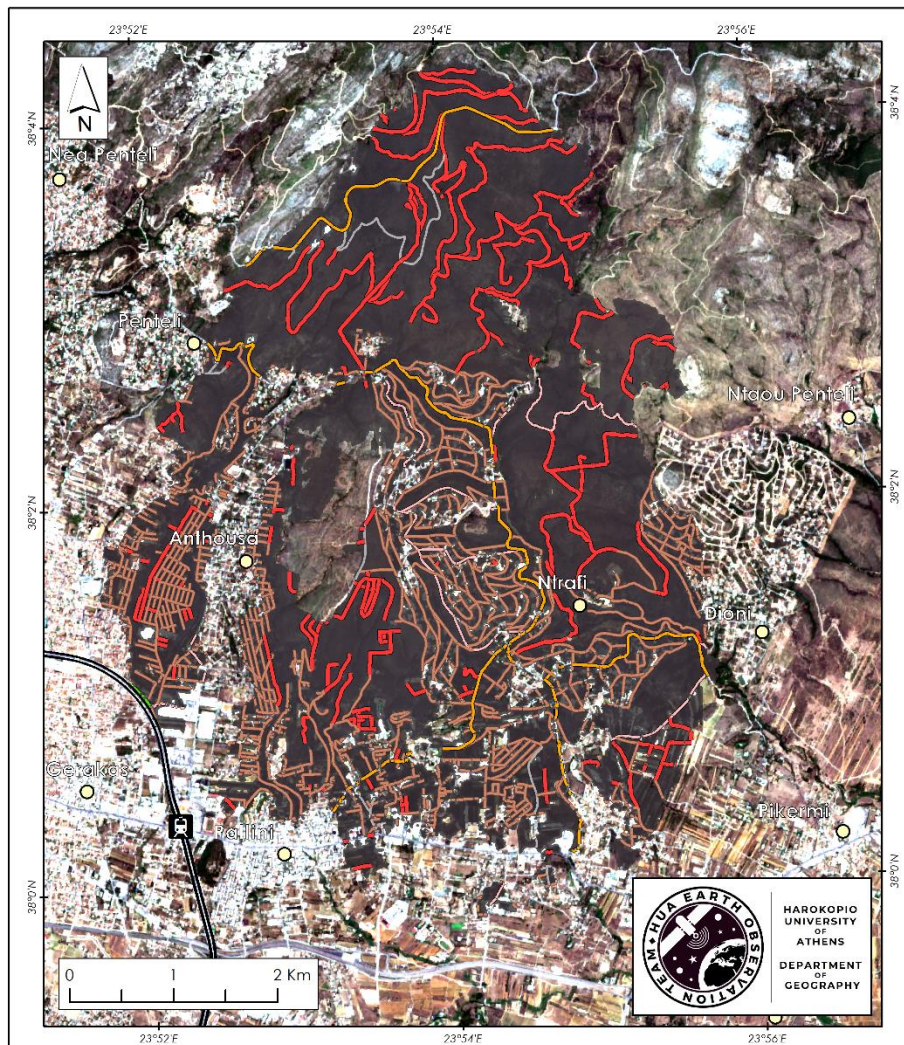
Projection:
 WGS 1984 UTM Zone 34N

July 2022



TRANSPORTATION NETWORK IN PENTELI FIRE-AFFECTED AREA

Transportation Network in Penteli, Athens Suburbs (Attica) - July 2022



Legend

- Settlements
- Railway Station
- == Railway
- Burned Area

Road Network

- Motorway
- Primary
- Secondary
- Tertiary
- Residential
- Local - Other



Transportation Network Mapping
(Roads Data: Open Street Map)

Background image:
Satellite Image of Copernicus
Sentinel-2B L2A 24/07/2022 12:06 EEST

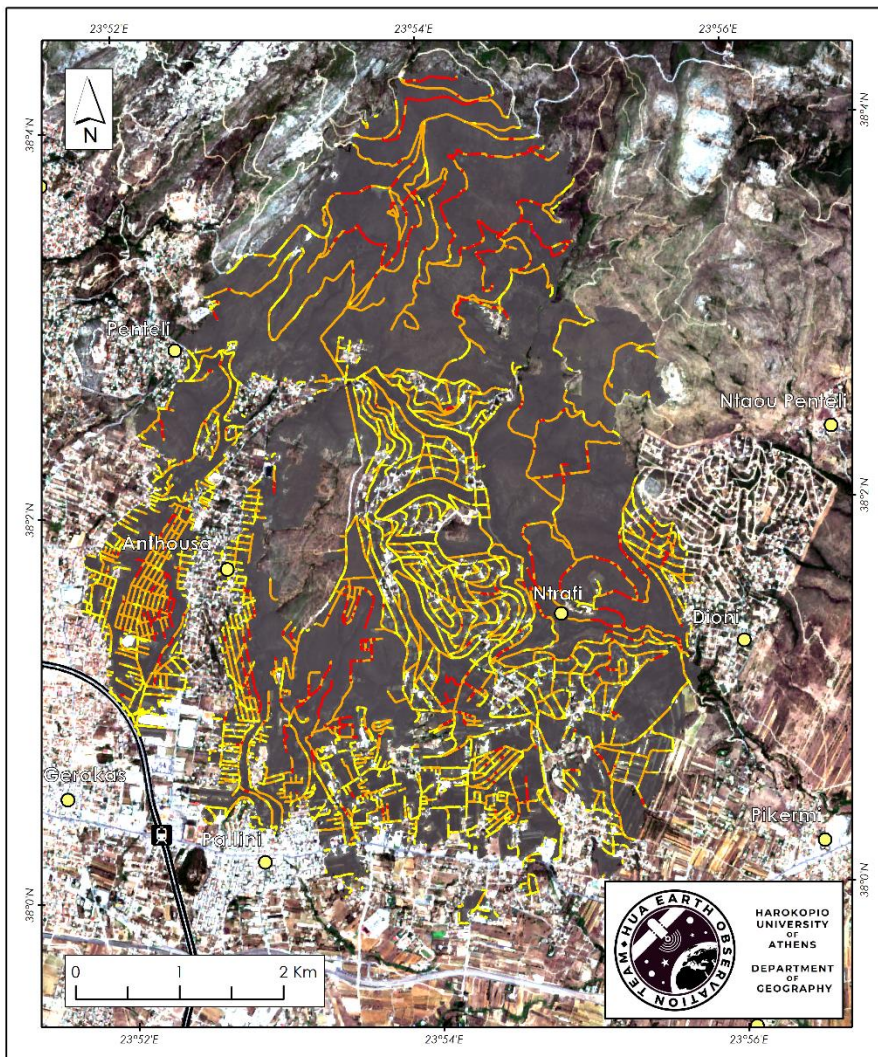
Projection:
WGS 1984 UTM Zone 34N

July 2022



ROAD NETWORK IN PENTELI FIRE-AFFECTED AREA

Road Network Exposure in Penteli, Athens Suburbs (Attica) - July 2022



Legend

- Settlements
- Railway Station
- Railway
- Burned Area
- Road Network according to Burn Severity**
 - Low
 - Moderate - Low
 - Moderate - High
 - High

Roads according to Burn Severity	Length (km)	Percentage (%)
Low	112.69	49.61
Moderate - Low	97.37	42.87
Moderate - High	17.05	7.51
High	0.03	0.01

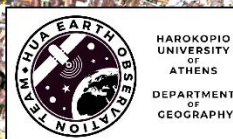


Roads Exposure according to Burn Severity
(Roads Data: Open Street Map)

Background image:
Satellite Image of Copernicus
Sentinel-2B L2A 24/07/2022 12:06 EEST

Projection:
WGS 1984 UTM Zone 34N

July 2022





INFRASTRUCTURE EXPOSURE, TRANSPORTATION NETWORK AND ROAD NETWORK EXPOSURE RESULTS BASED ON THE PREVIOUS ANALYSIS

Infrastructure Exposure

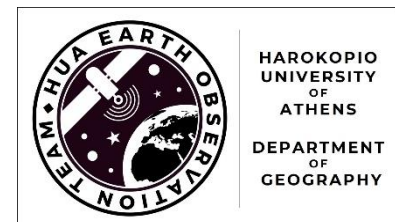
- According to Urban Atlas 2018, the affected infrastructure consisted mainly of Discontinuous medium density urban fabric (code: 11220) with 31.65%.
- Other roads and associated land (24%).
- High-resolution Infrastructure land types from Urban Atlas 2018 were used.
- Source: Urban Atlas 2018 – Copernicus Land Monitoring Service

Transportation Network

- The wildfire affected significantly the transport network, mainly residential (132 km) and primary (57 km) network.
- Source: Open Street Map

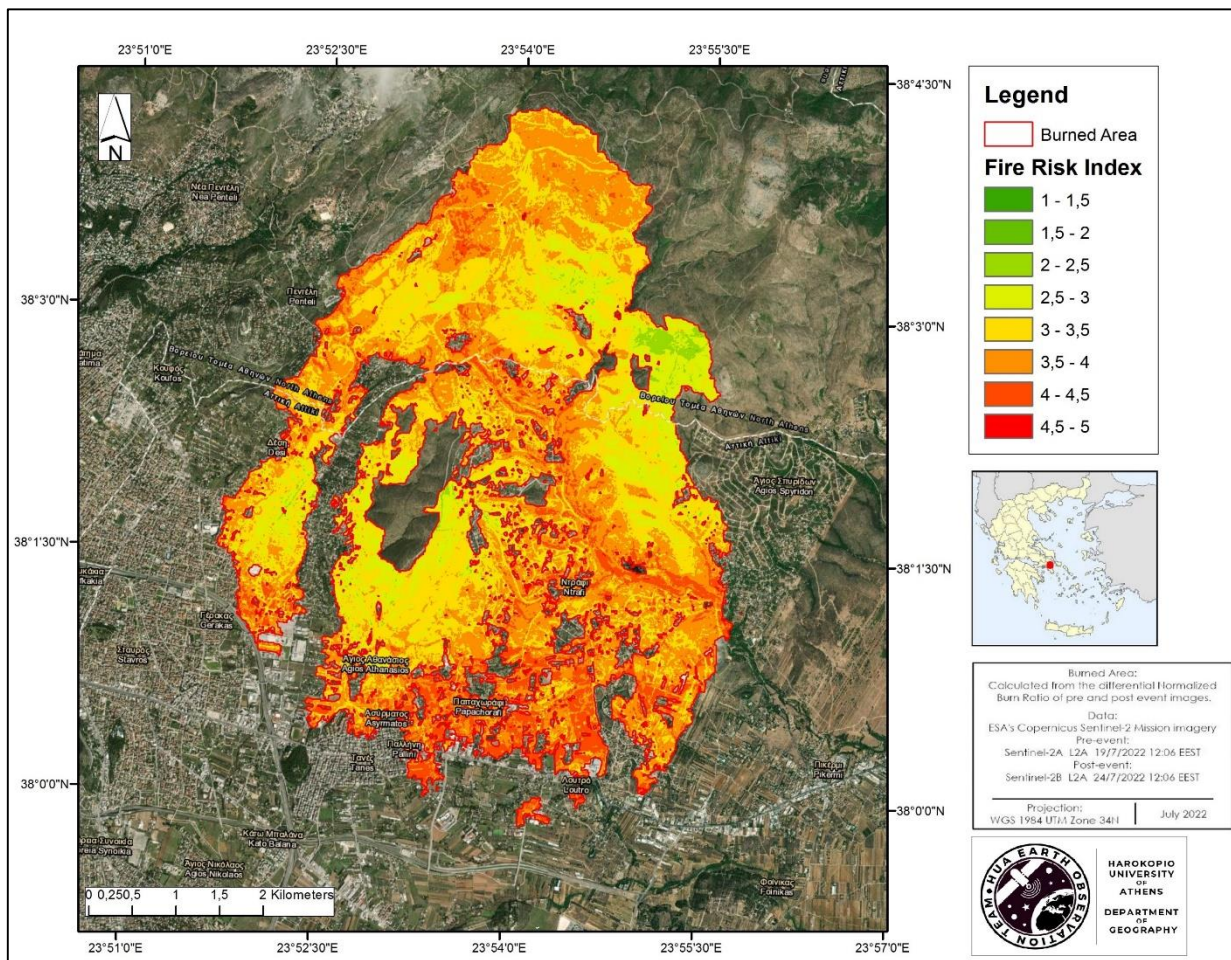
Road Network Exposure

- Most of the road network is characterized by Low Severity (49.61% or 112.69 km) and 42.87% (97.37 km) by Moderate – Low Severity.
- Source: Open Street Map





FIRE RISK MAP CALCULATED FOR ATTICA REGION CLIPPED TO THE BURNED AREA



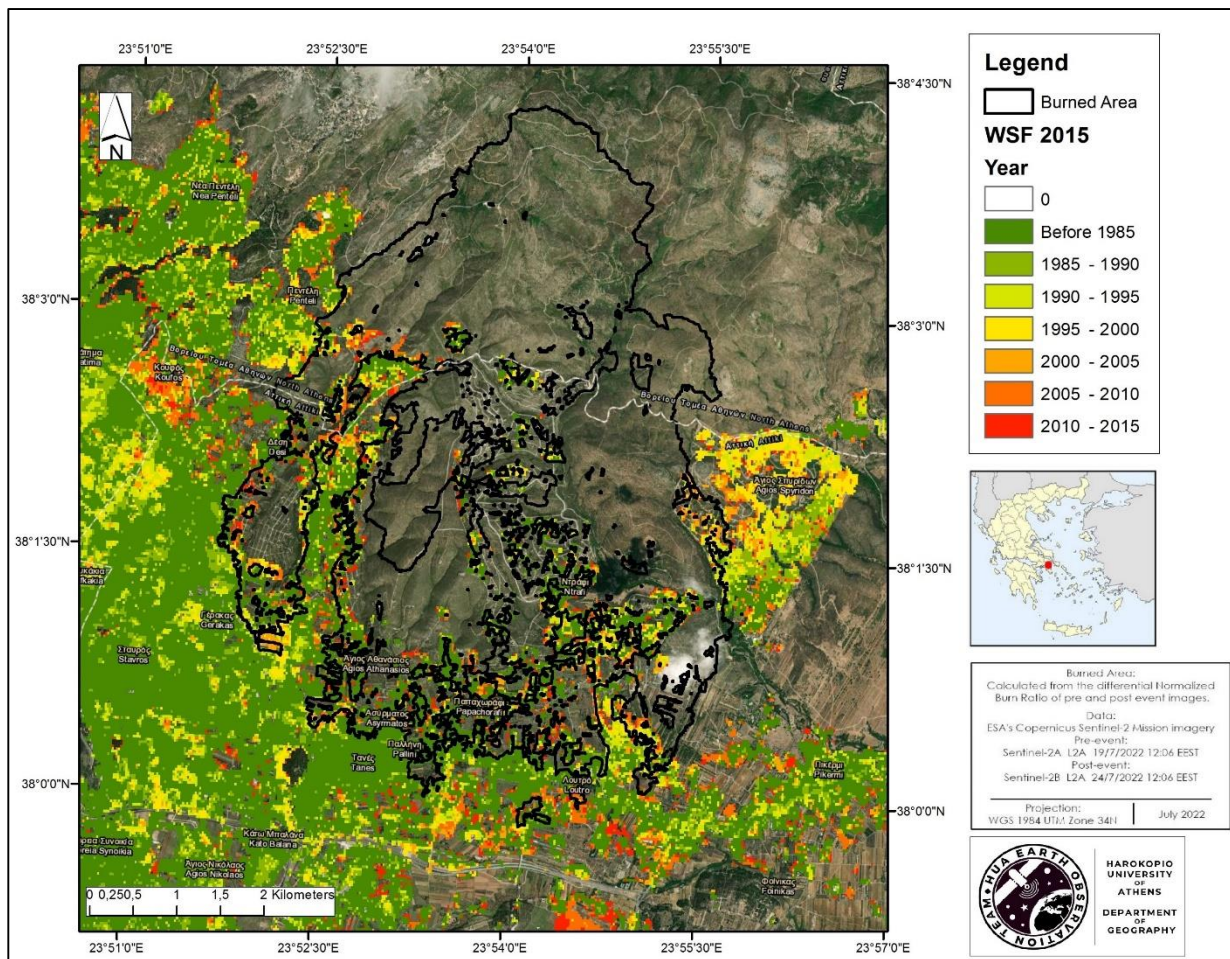
The fire risk is estimated based on **3 factors** and **7 criteria**:

- **DEM Derived factor:**
 - Aspect
 - Slope
 - Elevation
- **Land Use Factor:**
 - Corine Land Cover 2018.
 - NDVI derived from Sentinel-2 images
- **Socioeconomic Factor:**
 - Distance from major roads.
 - Distance from Settlements.

Weights were determined with the use of the **Analytic Hierarchy Process**



WORLD SETTLEMENT FOOTPRINT 2015 EVOLUTION MAP



The map shows the urbanization trend of the Penteli area. The burned settlements appear at the edges of the city where the new houses are located near the wildland.

The construction outside the city plan, the absence of protective measures, and arsons are the main reason for the burned settlements in Penteli.

World Settlement Footprint 2015 evolution:

- Derived by NASA/USGS Landsat satellite images between 1985-2015
- Illustrates the growth of human settlements year by year.
- Source: ESA and DLR in cooperation with Google Earth Engine

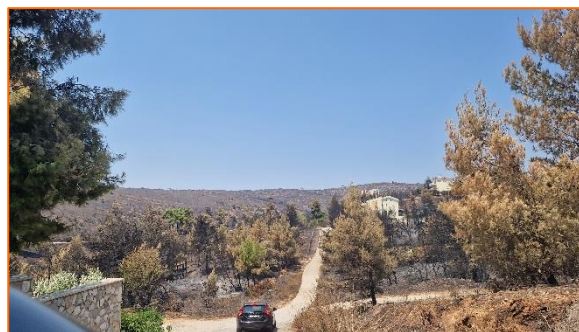
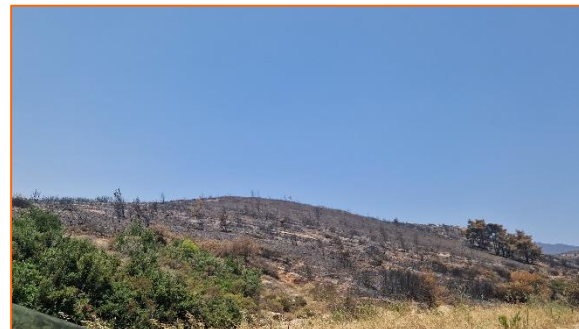


PRE-FIRE AND POST-FIRE IMAGERY OF THE FIRE-AFFECTED PENTELI

Pre-fire (Google Street View)



Post-fire





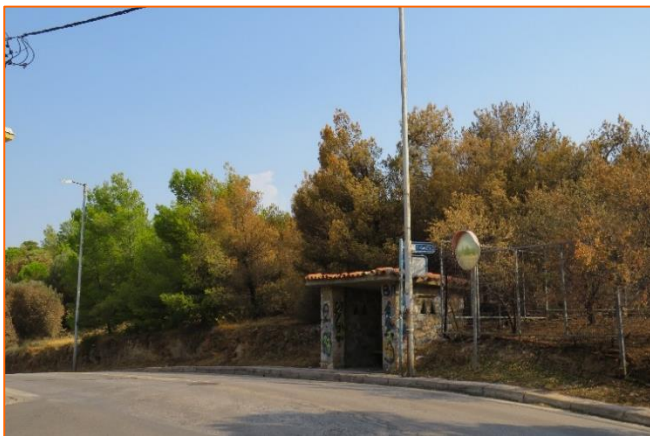
BUILDINGS AND THEIR SURROUNDINGS **CONDITIONS AND BUILDINGS PROPERTIES THAT LED TO MITIGATION OF IMPACT**



In most cases in the fire-affected area, the surroundings of the buildings were free of combustible objects and comprised only low vegetation at a distance from the outer walls of the buildings. This allowed the fire to reach the perimeter walls of the buildings' surroundings without affecting the structural and non-structural elements of the structures.



IMPACT ON THE NATURAL ENVIRONMENT

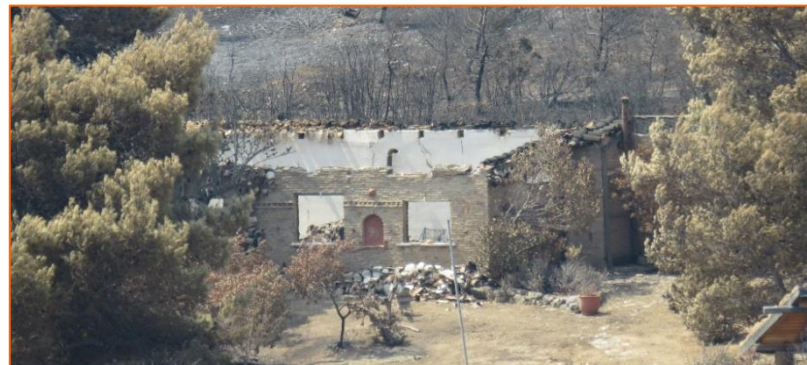


The impact on the fauna concern mainly shrubby and herbaceous vegetation.

- Adult trees are located locally, especially along the streams. The majority of them were partially burned, (foliage and trunk).
- Young trees (2-5 years old), planted after the last fire in the area, were completely burned.

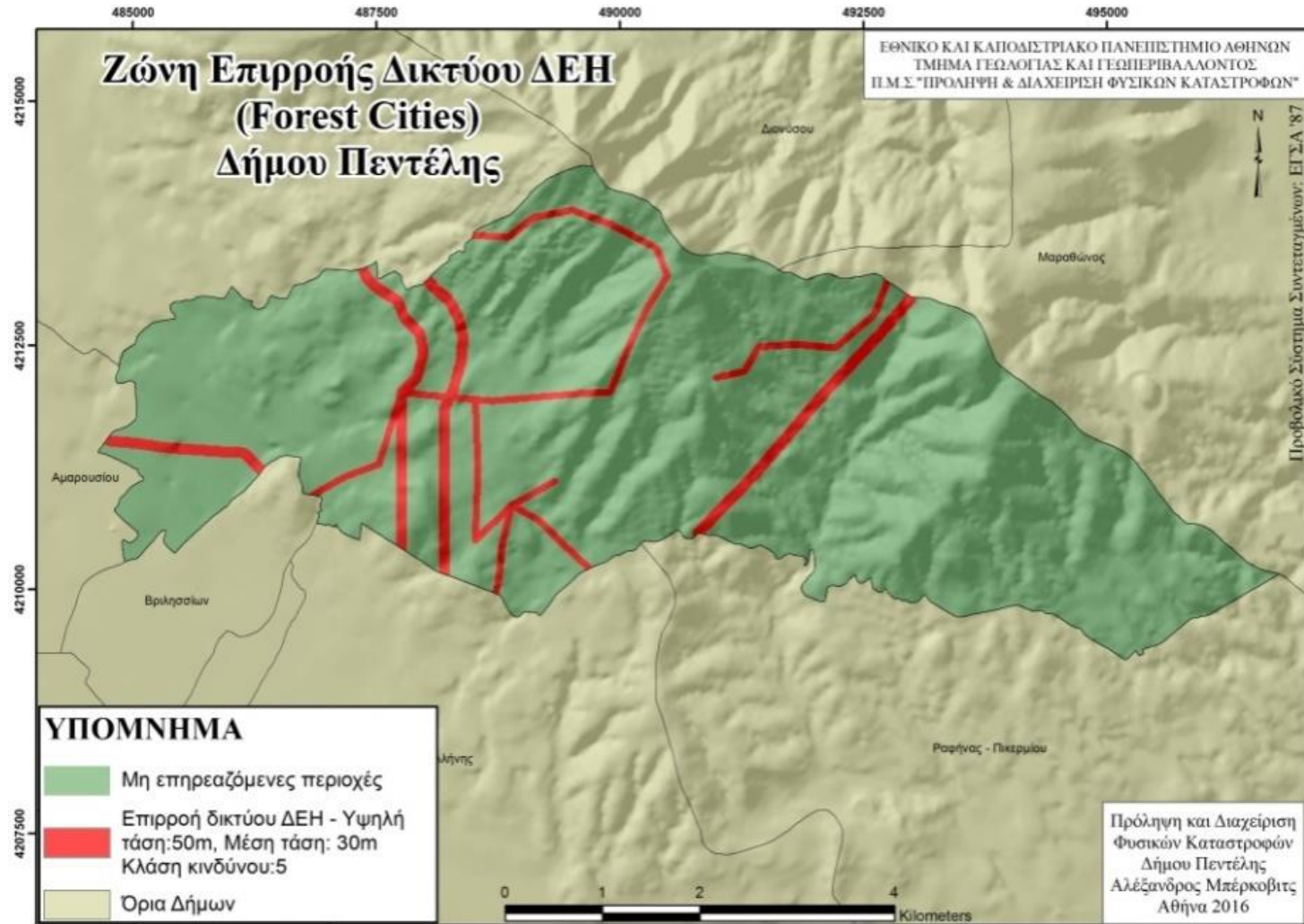


IMPACT ON BUILDINGS





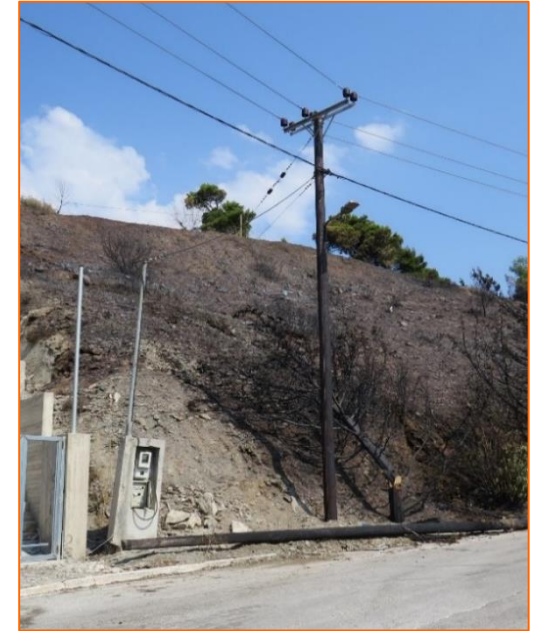
IMPACT ON INFRASTRUCTURE ELECTRICITY NETWORK



Green: Unaffected areas by electricity network. **Red:** the network line (high risk)



IMPACT ON LIFE LINES





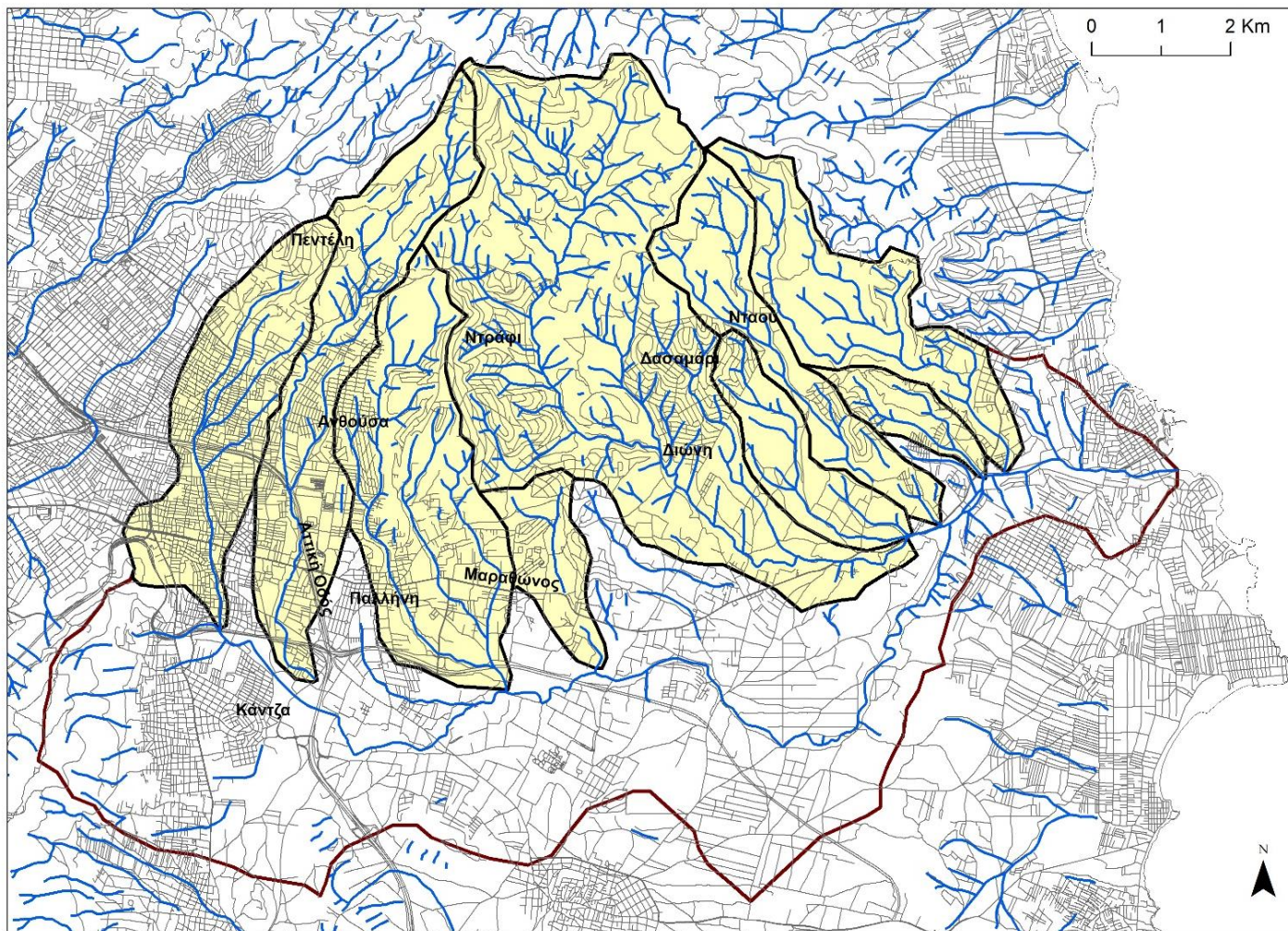
IMPACT ON VEHICLES



The melting of the aluminum and the car glasses is indicative of the high temperatures developed during the fire period



NATURAL HAZARDS EROSION AND FLOOD HAZARDS

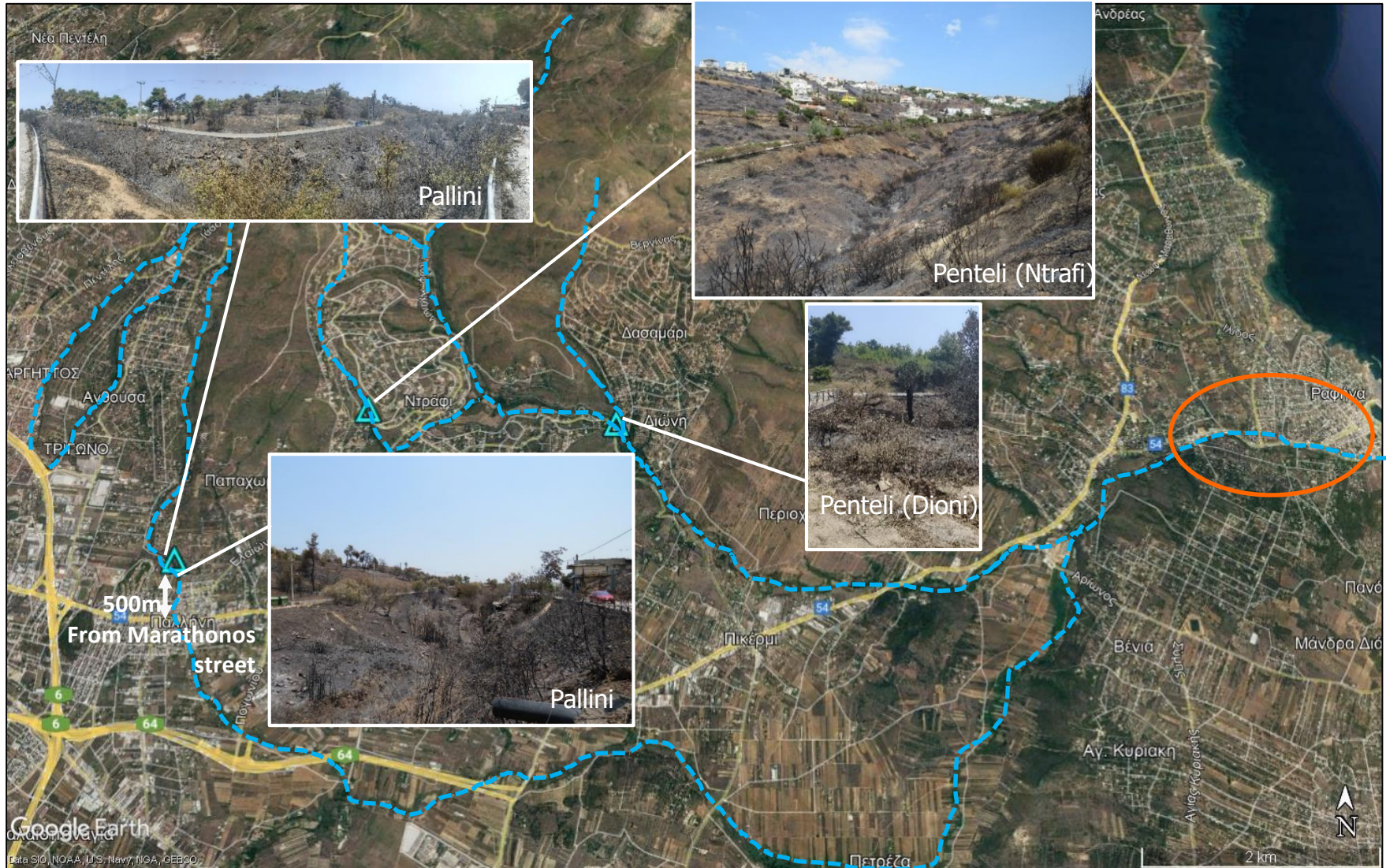


Local torrents draining the south and southeast slopes of Mt. Penteli were heavily affected by the fire.

At key locations surveyed (next slide), the cross sectional area is relatively narrow, increasing the probability of debris clogging phenomena, caused by vegetation fragments and other debris.



NATURAL HAZARDS EROSION AND FLOOD HAZARDS





ΣΥΜΠΕΡΑΣΜΑΤΑ

1. Πρόκειται για μια σοβαρή και επικίνδυνη δασική πυρκαγιά, η οποία κατέγραψε ένα θύμα, σημαντικές επιπτώσεις στο περιβάλλον και τη βλάστηση και σχετικά περιορισμένες επιπτώσεις σε κατασκευές και υποδομές.
2. Η πυρκαγιά επεκτάθηκε από τα υψηλότερα υψόμετρα της Πεντέλης προς τα χαμηλότερα, επεκτεινόμενη με μεγάλη ταχύτητα λόγω ισχυρών ανέμων με γενική διεύθυνση προς το Νότο, στα νότια και νοτιο-ανατολικά πρανή, φτάνοντας έως τις παρυφές των οικισμών Παλαιά Πεντέλη, Γέρακας, Ανθούσα, Παλλήνη και Διώνη.
3. Η κατάσβεση της πυρκαγιάς παρουσίασε χαρακτηριστικές δυσκολίες λόγω αναγλύφου, πολύ ισχυρών ανέμων και του είδους της χαμηλής βλάστησης, στην οποία η πυρκαγιά κινήθηκε με ταχύ ρυθμό, ενώ σημαντικό ρόλο διαδραμάτισαν οι γεωλογικές συνθήκες της περιοχής και οι έντονες μορφολογικές κλίσεις.
4. Τα πρώτα στοιχεία δείχνουν καλή διαχείριση και συντονισμό από πλευράς δυνάμεων κατάσβεσης.
5. Οι κατασκευές της περιοχής καταγράφουν χαρακτηριστικά που τις καθιστούν ανθεκτικές σε μεγάλο βαθμό απέναντι στην πυρκαγιά (δόμηση από οπλισμένο σκυρόδεμα, λίγα εύφλεκτα υλικά) και εκτός ελαχίστων περιπτώσεων, ένας μεγάλος αριθμός κατοικιών που ήρθε σε άμεση επαφή με την φωτιά δεν παρουσίασε επιπτώσεις.
6. Ο εξαιρετικά μικρός αριθμός βλαβών σε κτίρια εκτιμάται ότι οφείλεται στο ότι η πυρκαγιά ήταν κατά κύριο λόγο έρπουσα, με σχετικά αραιή καύσιμη ύλη, τα κτίρια παρουσιάζουν ανθεκτικότητα αλλά και στους χειρισμούς και την επιτυχημένη προσβολή της πυρκαγιάς από τις δυνάμεις κατάσβεσης.
7. Η ένταση της πυρκαγιάς σε ό,τι αφορά τον εδαφικό μανδύα εκτιμάται ότι δεν έλαβε πολύ υψηλές τιμές.
8. Λόγω της εκτεταμένης επίδρασης στο τοπικό υδρογραφικό δίκτυο και στις λεκάνες των νότιων πρανών της Πεντέλης αναμένεται να αυξηθούν τα φαινόμενα κατολισθήσεων, λασπορροών με φερτά υλικά, το φράξιμο υδατορεμάτων από θραύσματα βλάστησης και η σημαντική ενίσχυση της έντασης και συχνότητας των πλημμυρών σε βάθος αρκετών ετών.



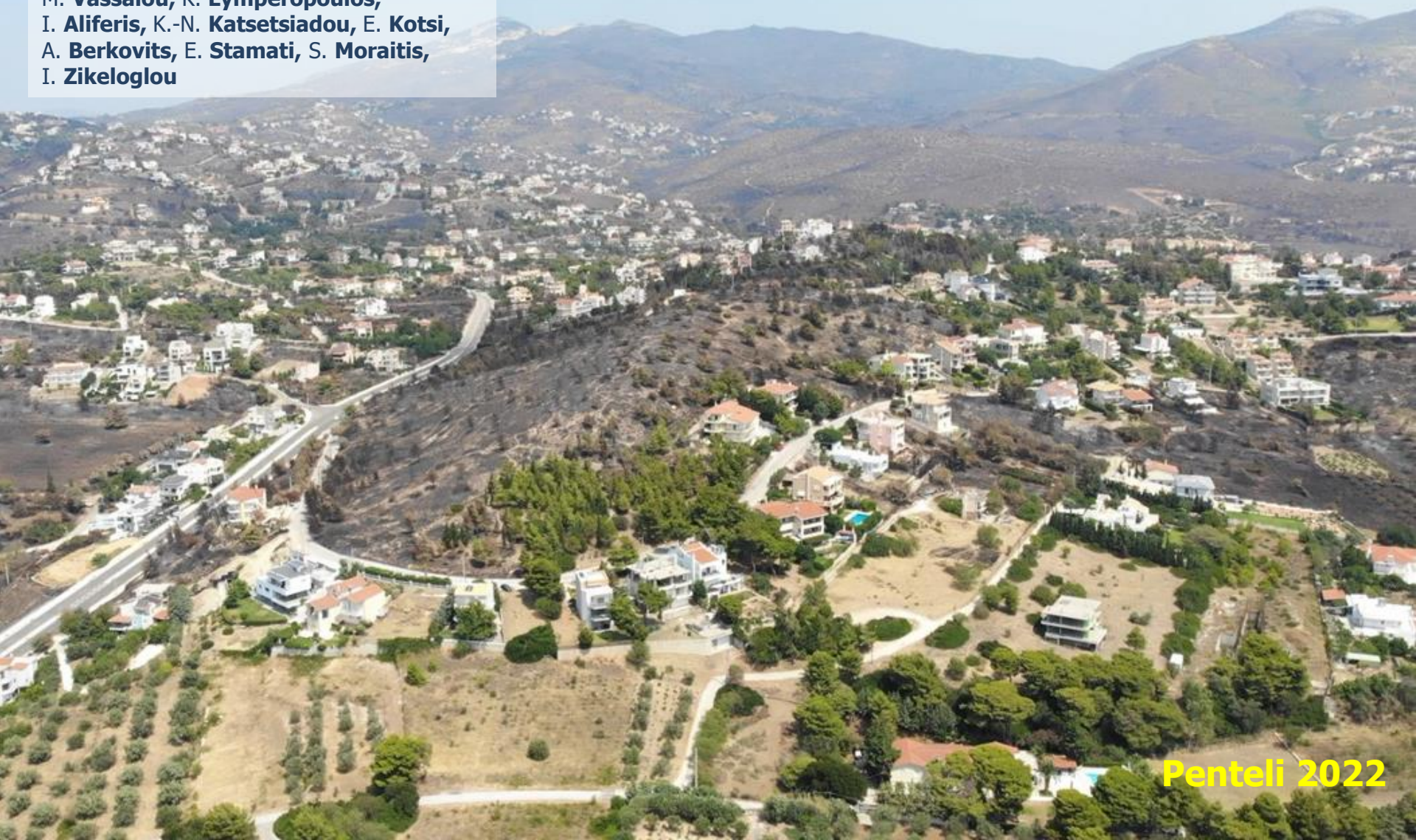
CONCLUSIONS

1. The fire of 19th July 2022 in the southern slopes of Penteli Mt. was an important and highly-dangerous event (with one victim) with significant impact on the environment, vegetation, infrastructure, as well as on a number of buildings.
2. The fire started from higher altitudes and extended southwards through the S and SE slopes of Penteli towards the towns of Gerakas, Anthousa, Pallini, Dioni and Palaia Penteli to the west.
3. Firefighting presented difficulties due to the local sharp relief and the strong north winds. The fire front moved with high velocity in low-vegetation areas. The geological and geomorphological conditions played an important role in the evolution of the fire extent.
4. Preliminary data indicate satisfactory management and coordination in terms of fire-fighting despite the above difficulties.
5. The vast majority of buildings situated in the burned area, were built with high-quality materials (mostly reinforced concrete, aluminum frames etc.) few of which were flammable. Their characteristics made them more resilient to the fire.
6. The small percentage of buildings that suffered damages is attributed to the fact that there were relatively small amounts of fuel in the area, the characteristics of the fire itself (surface fire not reaching the crowns of trees), the resilient characteristics of the buildings and the successful fire-fighting efforts of fire-fighting forces, authorities and volunteers. N
7. The fire intensity did not reach high levels in terms of soil burn severity based on qualitative observations in the field.
8. Due to extensive burning of a high percentage of the local drainage network and catchments, it is highly likely that runoff and erosion conditions will worsen in the south and southeast slopes of Penteli Mt. It is expected that debris flows, landslides and flood risk will increase and the area has the potential to see a higher frequency of hydrogeomorphic phenomena in the next years, especially if no prevention measures are taken.



E. Lekkas, S. Lozios, I. Parcharidis,
M. Diakakis, S. Mavroulis, N.-I. Spyrou,
M. Gogou, T. Falaras, K. Vorgiopoulou,
M. Vassalou, K. Lymperopoulos,
I. Aliferis, K.-N. Katsetsiadou, E. Kotsi,
A. Berkovits, E. Stamati, S. Moraitis,
I. Zikeloglou

The July 19-20, 2022 Penteli (Attica, Greece) Wildfire



Penteli 2022