

POST-FIRE VEGETATION RECOVERY MAPPING USING MULTI-TEMPORAL SENTINEL-2A IMAGERY IN CHIOS ISLAND, GREECE

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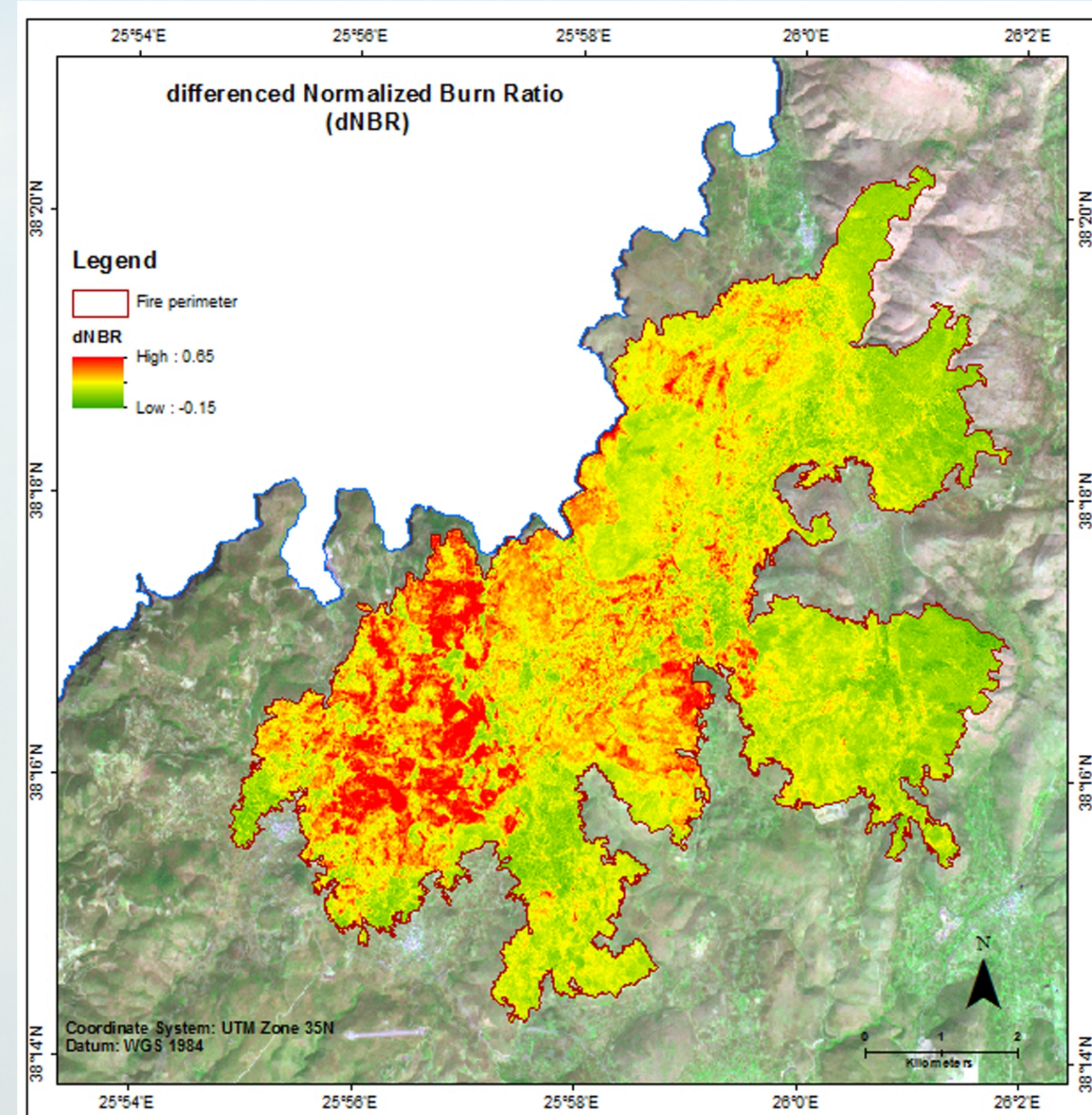
ABSTRACT

Remote sensing techniques offer the opportunity to study fire effects and vegetation recovery dynamics across large areas, providing essential information for effective management strategies development over fire-prone landscapes. Chios, the fifth largest of the Greek islands, has experienced recurring forest fires during the recent years, resulting to significant risk of environmental degradation. During the summer of 2016, the island experienced two severe wildfires, with the biggest one recorded in the southern part of the island. The affected area was mostly covered by maquis and phrygana (formations of low shrubs) (40.9%), while pine forests (*Pinus brutia*) represented 15.5% of the burned area.

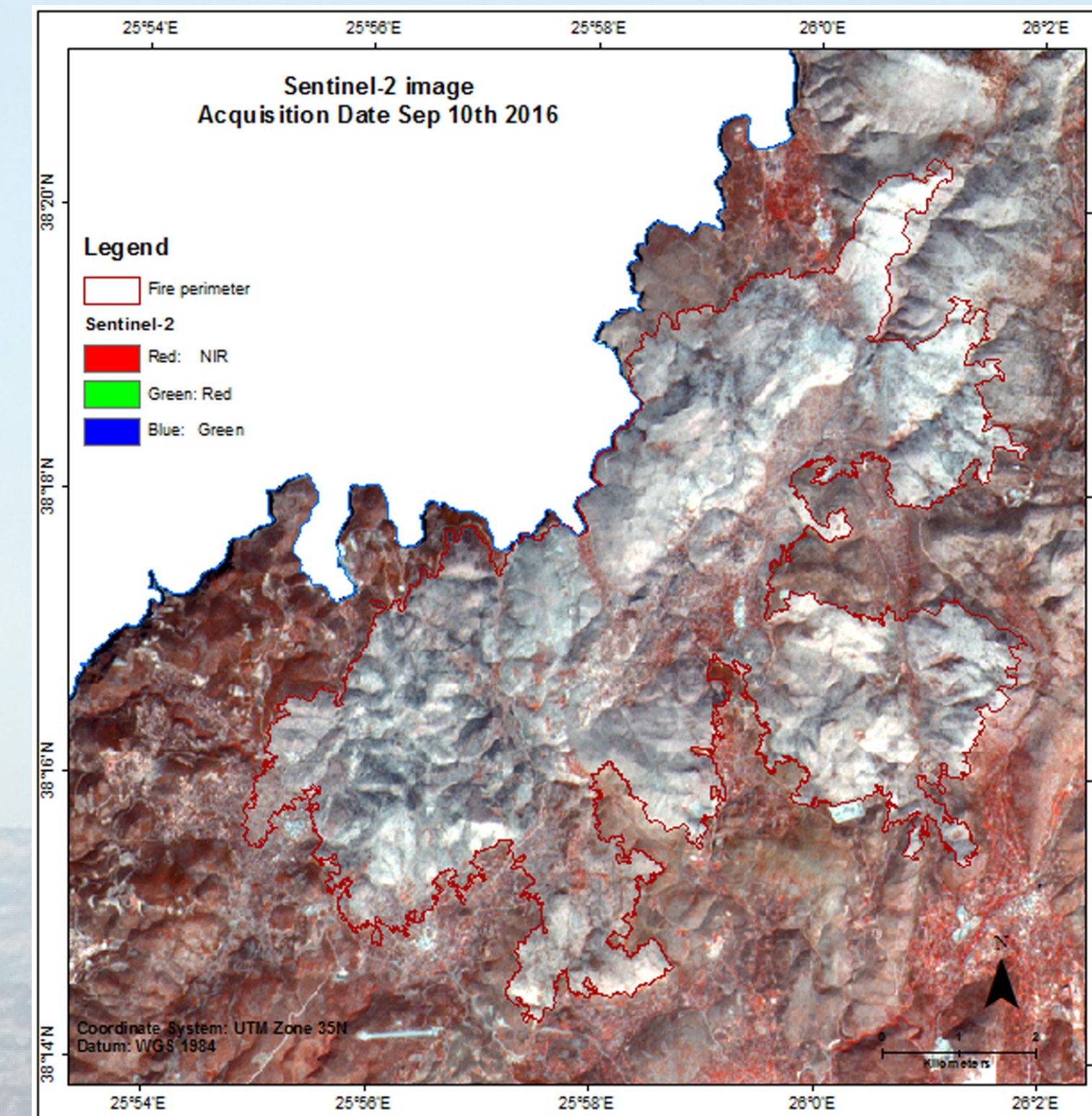
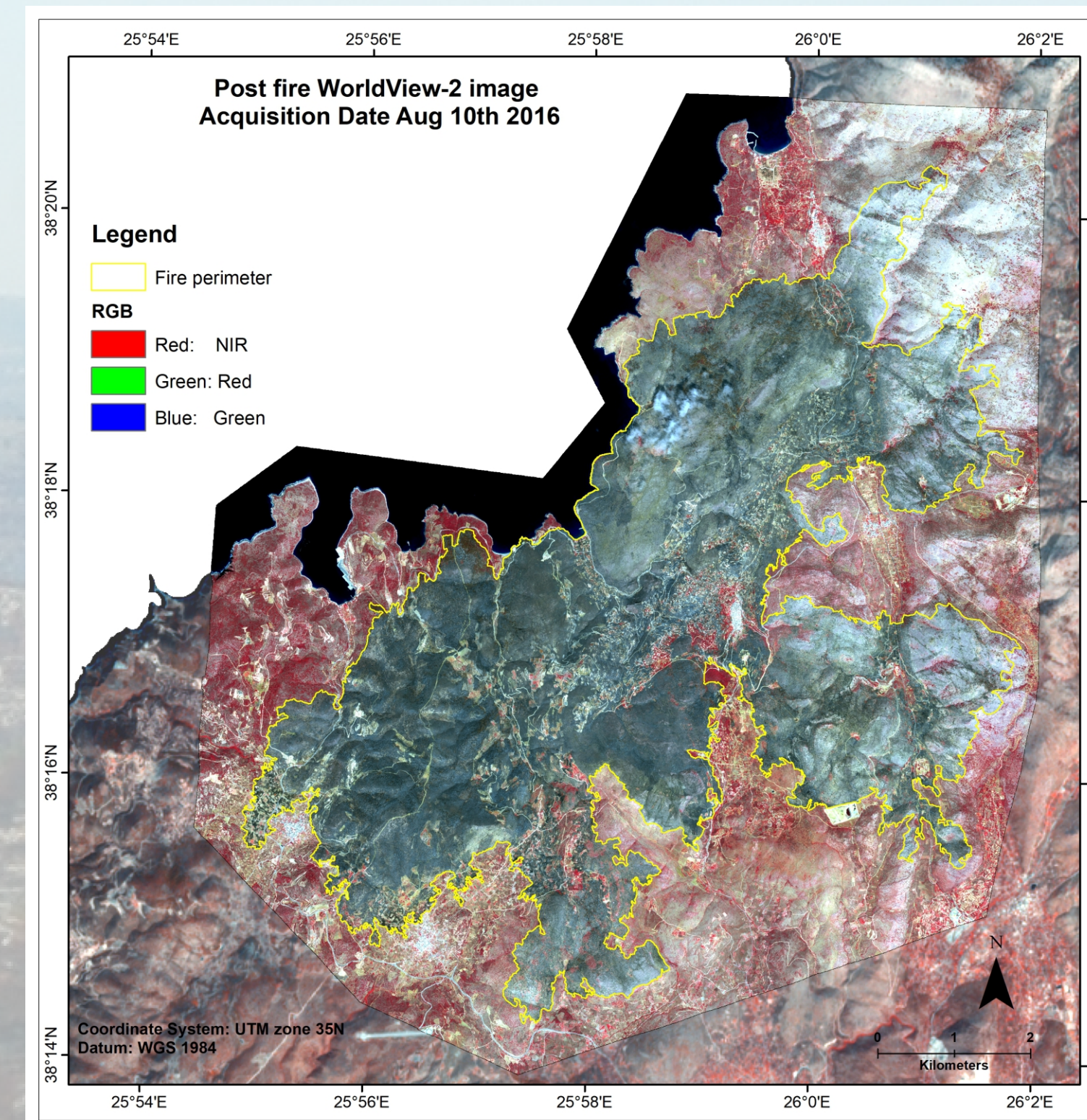
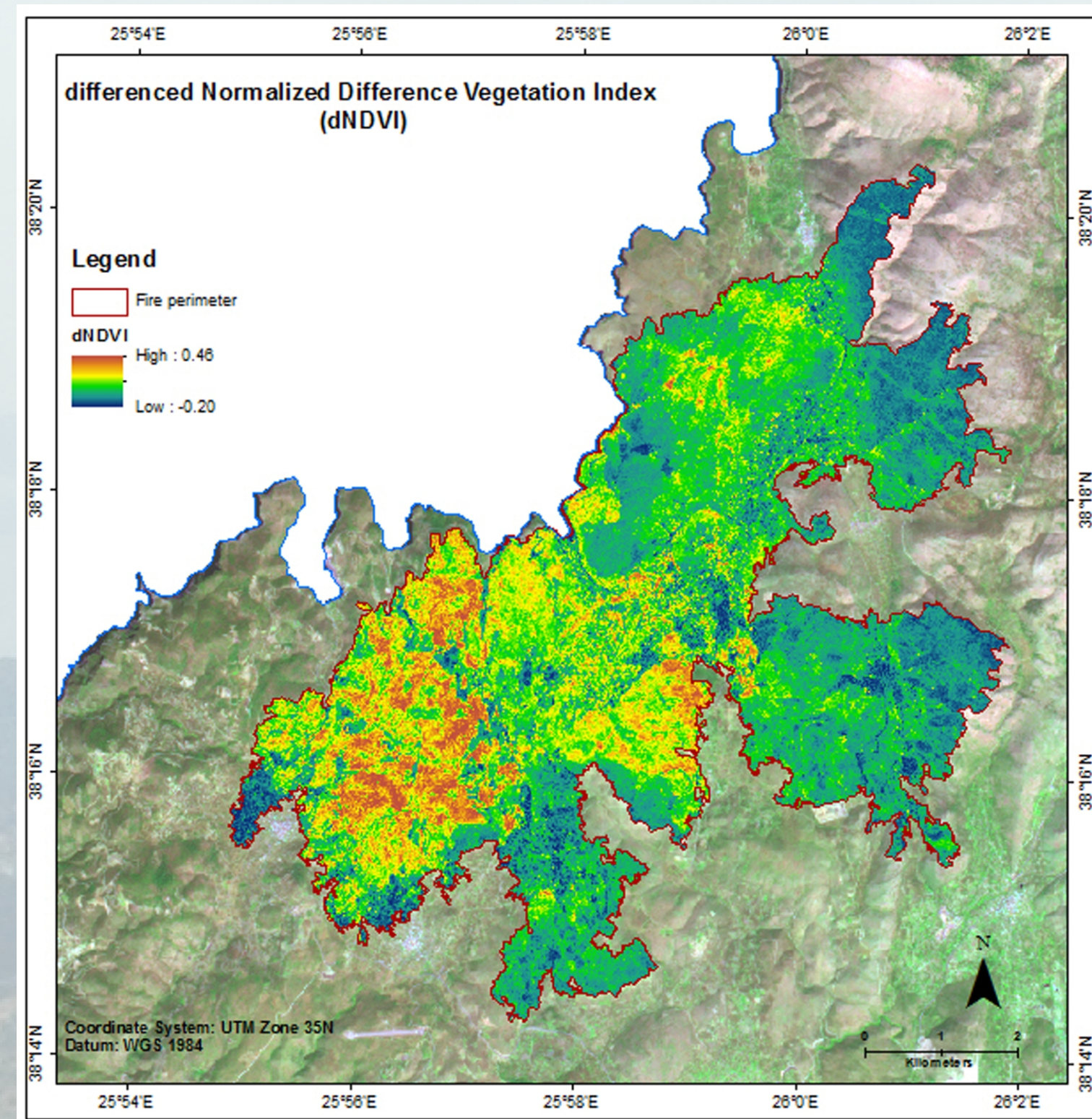
The aim of this study was to estimate and analyze the state of post-fire vegetation recovery in the island of Chios following major fire events occurred during the summer of 2016. A post-fire 8-band **WorldView-2** image was used for burned area mapping by employing a geographic object-based classification approach, followed by field campaign for assessing post fire vegetation recovery, which was conducted during summer 2017 by establishing reference plots in the main pre-fire vegetation types (maquis, shrublands and pine forest areas) within the fire-affected area.

A series of single and multi-temporal spectral indices including Normalized Burn Ratio, Normalized Difference Vegetation Index, Enhanced Vegetation Index and Soil Adjusted Vegetation Index, were derived from multi-temporal **Sentinel-2** images. A random forest modelling procedure was performed for estimating post fire vegetation recovery within the burned area, as well as the areas of high risk erosion.

We identified dNDVI, EVI and the second red edge band of **Sentinel-2** as the most important spectral variables for predicting vegetation recovery within pre-fire areas. In the case of pre-fire areas with maquis, post-fire NBR, EVI and NDVI were selected as best predictors. Finally, the results revealed that vegetation recovery is more pronounced within the pre-fire pine forest areas, while topographic and geological sub-strata factors were also found significant in defining post-fire vegetation recovery.



Dense canopy *Pinus brutia* forest that has been burned only once during the last years, with low fire severity.



Quercus coccifera resprouts vigorously from rhizomes after fire.



Medium canopy *Pinus brutia* forest that was burned only once during the last years, with medium fire severity.



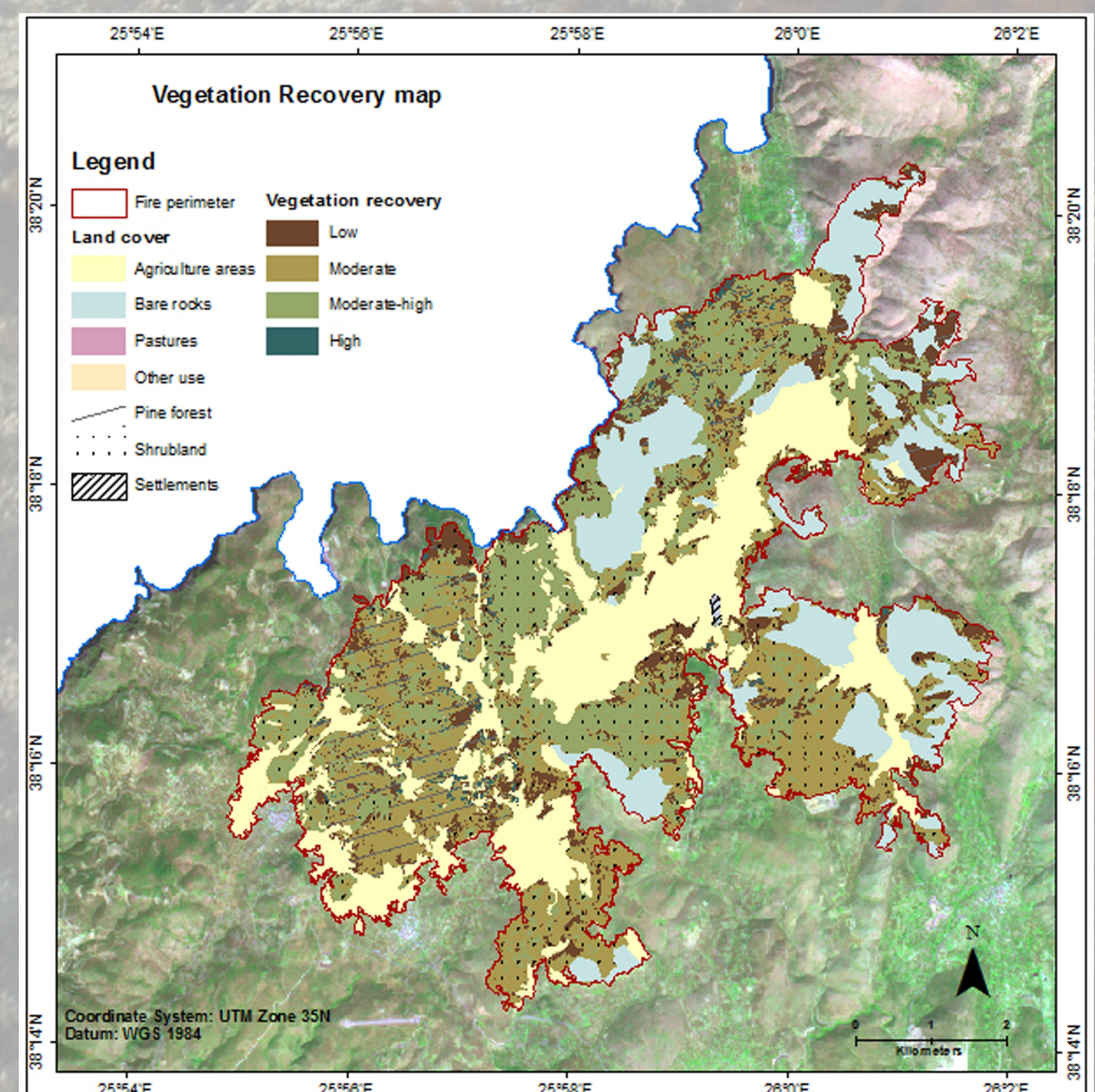
Dense canopy shrublands that were burned only once during the last years, with high fire severity.



Sparse canopy shrublands that were burned twice during the last years, with medium fire severity.



Density of pine seedlings (ind/m²) of this site suggests that the post-fire vegetation recovery will be high enough to result in complete natural recovery (recovery class high). Unburned litter as well as the open cones lying on the ground suggests that fire severity at this site was rather low.



Post-fire vegetation recovery assessment was conducted within the borders of natural vegetation types: *Pinus brutia* forests and shrublands based on field measurements and remote sensing analysis. Shrubland represent both dense and sparse shrubs. Dense shrubs are mostly covered by maquis, while sparse shrubs are mostly covered by phrygana.

Assessment of post-fire regeneration for *Pinus brutia* forests and shrublands, was based on field measurements. Vegetation recovery was classified into four (4) categories following specific criteria for each of the vegetation types, as presented in the following Table.

Criteria used for assessment of post- fire regeneration	
Pine forests	Shrublands
Pre- fire canopy cover (sparse- medium- dense)	Pre- fire canopy cover (sparse- medium- dense)
Number of fires (1-2)	Number of fires (1-2)
Fire severity (low- medium-high)	Fire severity (low- medium-high)
Post- fire regeneration of dominant tree (mean sapling and seedlings density / m ²)	Post- fire cover of woody species (%)



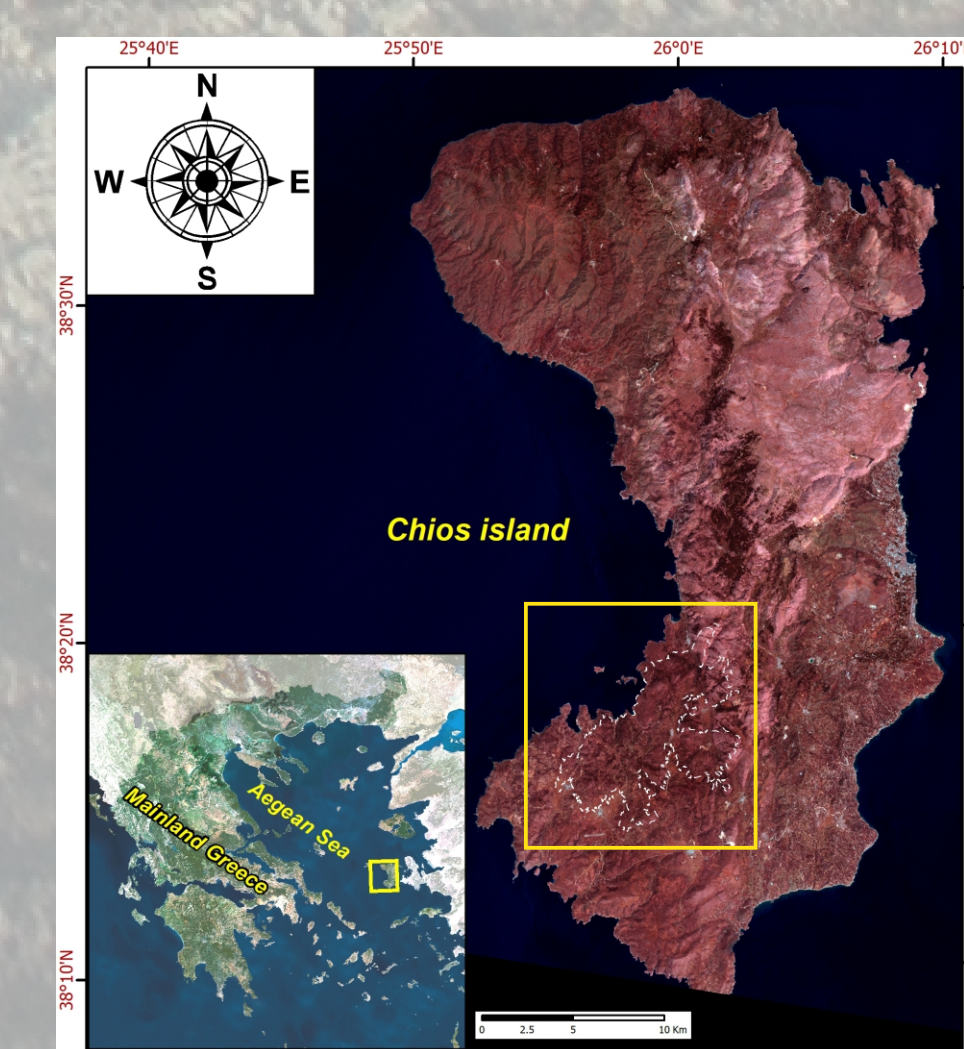
Pinus brutia and *Cistus* spp. regeneration by seed germination.



Pinus brutia and *Cistus* spp. post- fire regeneration by seed germination. Seedlings density implies a rather medium recovery level, while black ground, black burned tracks as well as the lack of any litter on the ground suggests that fire intensity at the site was rather medium to high.



Most of the shrub species regenerated through resprouting.



Landsat-7ETM+ image of Chios island (521/RGB), acquired on 7/6/2000. The dashed line surrounds the 2016 fire event. The inset map shows the location of the Landsat image in the eastern Aegean Sea. The yellow outline of all maps presented here is also displayed.