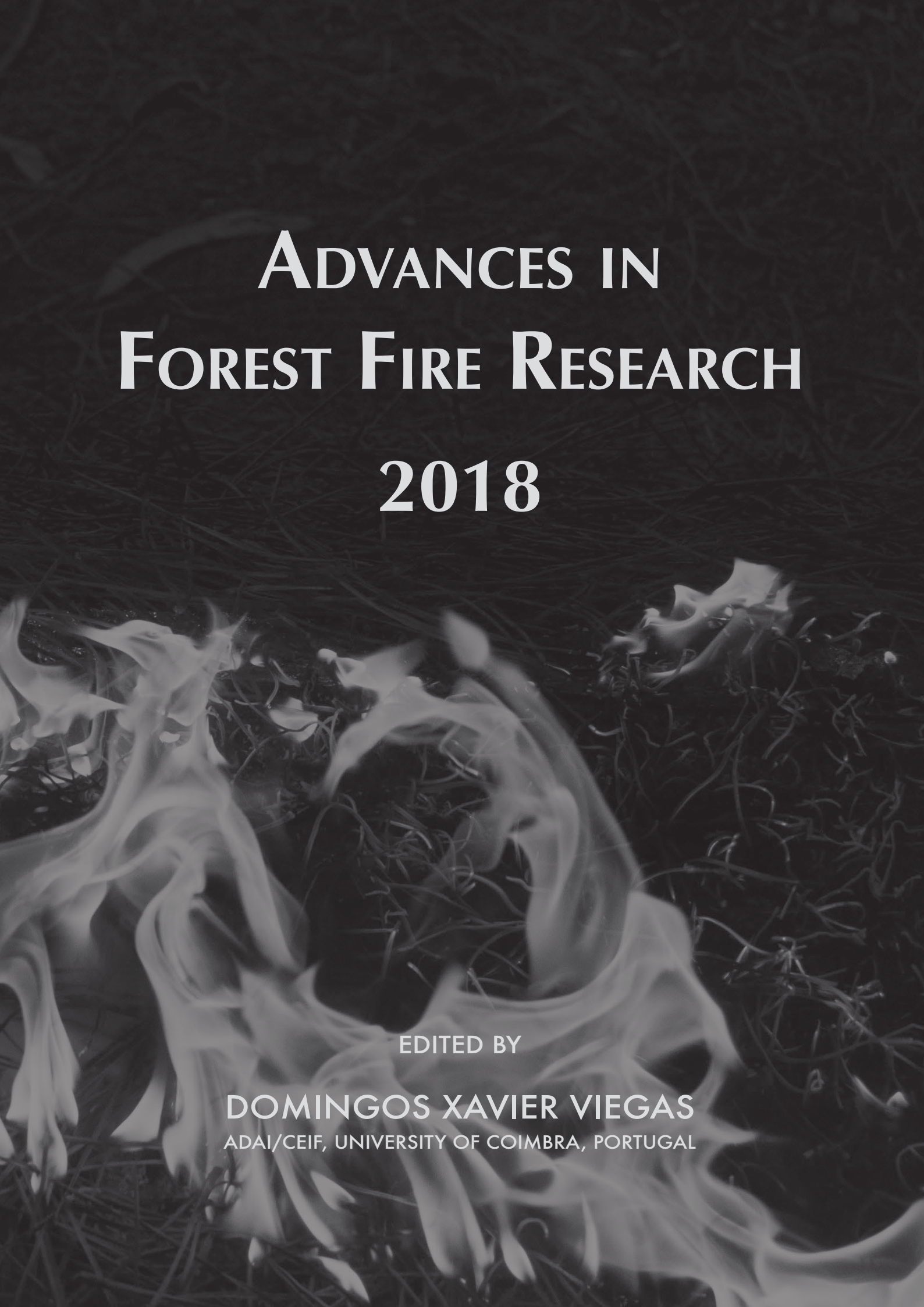
Advances in Forest Fire Research 2018



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Short contribution – Decision Support Systems and Tools

Understanding fire, weather and land cover interactions from long-term terrestrial observations and satellite data on a transect from Europe to North Africa

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Keywords: Long-term documented historical fire records, Switzerland, Greece, Algeria, Tunisia, remote sensing, generalized linear models, extremes, climate, fire selectivity.

1. Project overview

Long-term historical time series records of fire activity (number of fires and total area burned) extending back to the late 1800s, that are very rare worldwide, were found and used within the GRADIENT project that correspond to (i) Switzerland, central Europe (1900-2014), (ii) Greece, south Europe (1897-2014), (iii) Algeria, north Africa (1870-2014) and (iv) Tunisia (1902-2015), north Africa which together with the spatial-explicit reconstruction of recent fire history from Landsat satellite images (1984-2016), gave a unique and excellent opportunity to understand fire, weather and land use/land cover (LULC) interactions in a north to south transect. The Tunisia study case was added during the implementation period of the project since in the original proposal only the first three study cases were proposed.

Differences in bio-geographical characteristics provided by the four selected study areas, located on a large geographical gradient covering two continents gave the opportunity to document the role of fire in different biomes, to explore cross-scale issues and assess how fire-weather-LULC interactions vary across different scales, especially under a climate change context. GRADIENT project consisted of three topics that correspond mainly to three different scales. The specific objectives were: (i) the identification of trends, patterns and relationships between forest fires, weather, land cover and socio-economic variables from long-term observations, (ii) the reconstruction of recent fire history and the assessment of burning patterns and fire selectivity on an annual basis from satellite images, and (iii) the exploration of post-fire vegetation dynamics and recovery for selected large fire events using time series satellite images.

1.1. Trends, patterns and relationships between forest fires, weather, land cover and socio-economic variables

There are similarities and non-similarities among the four study area that compose the gradient from north to south. In principle there is a characteristic fire activity in all four study areas defined by the general pyro-environment with certain peaks occurred at specific years associated to physical and social factors. The role of precipitation is different in the gradient from the wet to dry areas. Moisture is more evident as an underlying explanation mechanism in the wet study area while temperature is more evident in the dry study areas. It was evident that there is a clear and different role of precipitation from promoting to discouraging fire activity across the north to south gradient together with the social aspects and the role of human dimension.

Concerning the extremes, two clear patterns were observed according to the two discrete roles of the explanatory variables recognized previously; the first pattern where the role of the explanatory variable is to promote fire activity as the example of Switzerland with the effect of precipitation or dry period area promoting fires (e.g. drought) and the second pattern where the role of the explanatory variable is to discourage fire activity as the example of Greece or Algeria with the effect of precipitation or dry period area discouraging fires (e.g. wet conditions). We recognize a gradient from north (Switzerland) to south (Algeria) where the role of explanatory variable to fire activity is changing from promotion to discourage.

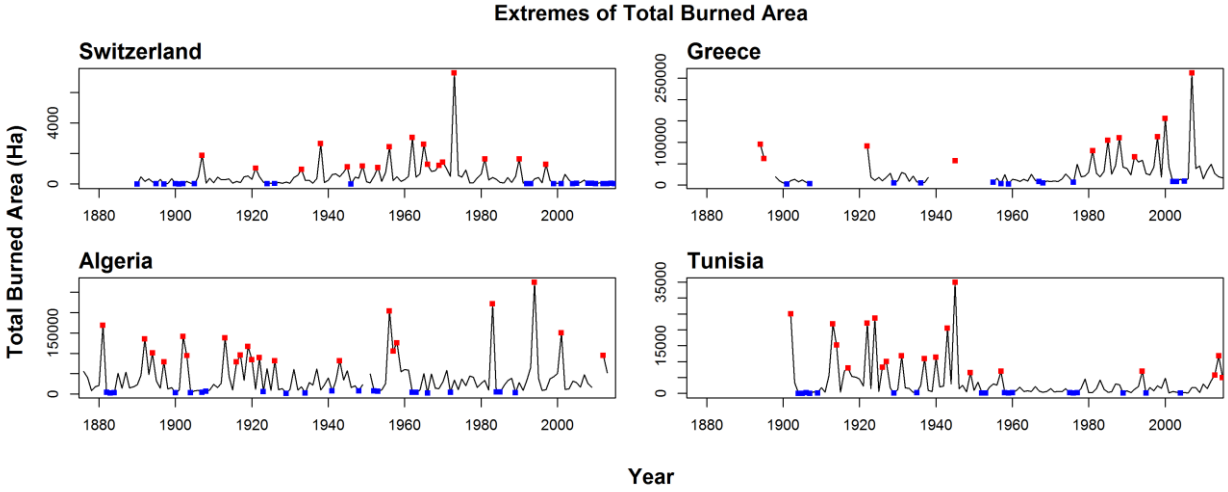

Figure 1 - The extreme years for both high and low fire activity at yearly basis for the four study areas. The distribution of the extreme years is similar to all countries: 14-18% is the range of the high extremes, 12-17% is the range of the low extremes and 67-74% is the range of the non-extremes which is the majority.

1.2. Reconstruction of recent fire history and the assessment of burning patterns and fire selectivity

The interactions of landscape components and fire were analyzed by comparing the relative proportions of what the fires burnt during the period 1984-2015 against what is available to burn across the landscape (e.g. CORINE, or other available global land cover data, e.g. ESA global land cover data), considering a random model that accounts for spatial autocorrelation. To determine whether the wildfires burn significantly different proportions of LULC classes than what is available to burn we applied a Monte Carlo randomization test considering spatial autocorrelation on the basis of randomizing the fire events using however the exact fire shape to account for the spatial autocorrelation. For all study area selective burning is evident that also depends on the available to burn landscape. Frequent fires were also observed that burn mainly grassland and shrublands.

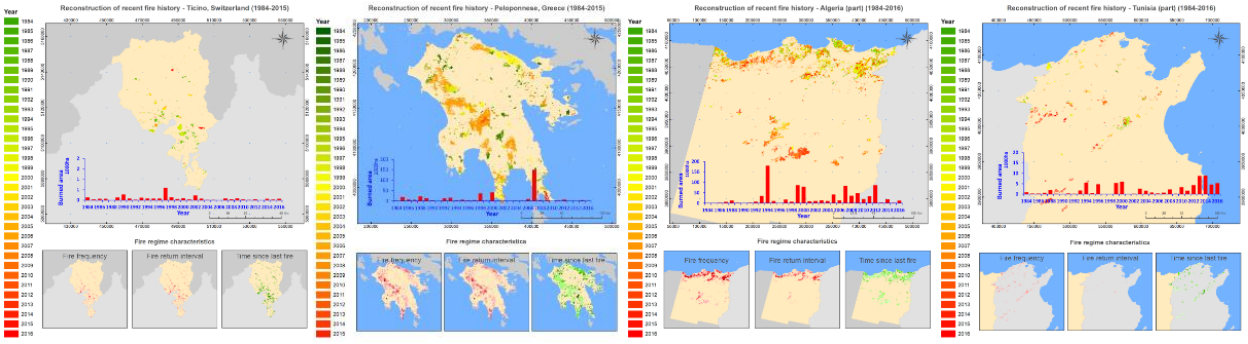

Figure 2 - Fire regime characteristics depicting (i) fire scar maps that include patterns of burned and unburned patches, (ii) fire frequency, (iii) fire return intervals, and (iv) time since last fire event.

1.3. Exploration of post-fire vegetation dynamics and recovery using time series satellite images

Satellite remote sensing data from MODIS and LANDSAT satellites in the period from 1984 to 2016 were acquired and processed to extract the temporal profiles of the spectral signal for selected areas within the fire-affected areas. This dataset and time period analyzed together with the time that these fires occurred gave the opportunity to create temporal profiles for almost half years before and half years after the fire. The different scale of the data used gave us the chance to understand how vegetation phenology and therefore the recovery patterns are influenced by the spatial resolution of the satellite data used.

Within the GRADIENT project vegetation phenology and time series statistics proved very useful not only to study vegetation recovery in fire affected areas but also to identify the time period where the fire or fires occurred and define also the vegetation phenology before the fire. This is very useful first for integrating this concept into a burned land mapping approach and second for identifying what type of vegetation is burned.

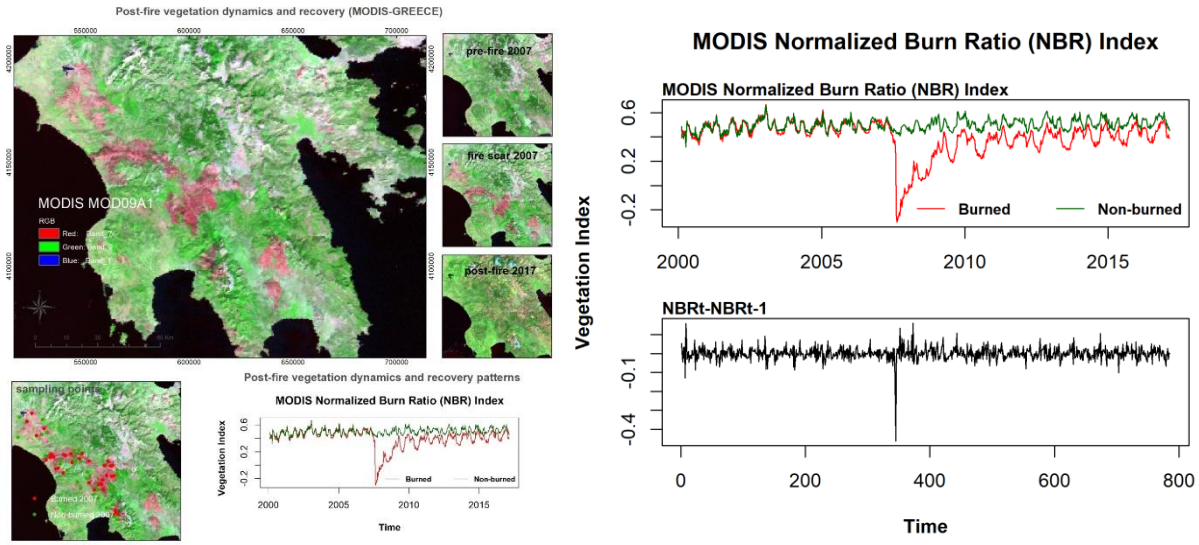

Figure 3 - Vegetation recovery of a 2007 fire in Greece using the phenology from the time series MODIS data. The date of fire occurrence is very well defined in the NBRt-NBRt-1 time series.