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Post-fire malleability analysis in Pinus halepensis ecosystem through multitemporal phenological metrics applied to MODIS GPP (MOD17A2H) product

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Abstract

The recovery of vegetation after a fire depends on the interactions and inhibitions of reproductive strategies of affected species, the biological legacy of the ecosystem, the severity or intensity of the fire, rainfall anomalies, and other variables related to the topographic-morphological context or applied anthropogenic actions. Throughout the recovery process, physio-taxonomic changes occur with direct implications for the amount of carbon fixed by colonizing formations based on the efficiency in the use of photosynthetic radiation. This amount of carbon can be quantified through the phenological analysis of inter- and intra-annual variations in gross primary production (GPP). The main objective of this study is to describe the interannual phenological variations of GPP in two *Pinus halepensis* fires located in the municipalities of Zuera (2008) and Luna (2015), in the province of Zaragoza. This analysis was conducted using a time series of the MOD17A2H product from the MODIS sensor (compounded every 8 days with a spatial resolution of 500 m), which quantifies the carbon fixed by ecosystems, taking into account variables such as incident solar radiation, surface reflectance, and temperature. We used data from the two years prior to the fire and the subsequent evolution, using pixels in burned and control areas (unaffected by the fire) to characterize the eco-physiological malleability of the ecosystems. Three phenometric variables calculated with TIMESAT 3.3 software were selected, corresponding to the season amplitude (the difference between the maximum and base values of GPP), the length of the season, and the integral of the annual spectral-phenological curve (from the GPP value of 0 to the maximum value within each season). The results of the phenometric analysis show significant differences between control areas and those affected by fire in dates after the fire (average GPP before the fire: 23.95 g C/m^2, post-fire: 17.14 g C/m^2). The effects of fire on the duration of the season and the amplitude of the GPP value during the season were transient. However, the integral of the spectral-phenological curve maintains significant differences for several years after the fire, indicating the

incomplete eco-physiological recovery of these ecosystems despite the regenerative effectiveness of *P. halepensis*. These results indicate that the analysis of GPP phenometrics can be a useful tool for studying the resilience of fire-affected forest ecosystems in terms of productivity.

Keywords: Land Surface Phenology (LSP), TIMESAT, Resiliencie, Time Series, Remote Sensing

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