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Predicting the severity of defoliation due to the pine processionary moth using remote sensing and UAV imagery

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Currently, pest is the principal biotic driver to cause disturbances in Mediterranean forests and may accelerate to tree mortality in a combination with other biotic factors as well as abiotic factors such as drought, fire, and climate change. The pine processionary moth (*Thaumetopoea pityocampa*), one of the major defoliating insects in Mediterranean forests, has become an increasing threat to the forest health over the past two decades. In a normal year healthy forest stands recover from defoliations, however, when host trees are stressed by other disturbance factors severely defoliated stands may not sufficiently recover in the following years, resulting in significant reductions of forest production and carbon stock. In the case of Catalonia, northeast of Spain, forest health surveys on *T. pityocampa* have been conducted annually at the regional scale since 2010. After the recent outbreak of *T. pityocampa* observed in 2016, we attempted to estimate the severity of defoliation by comparing pre-outbreak and post-outbreak images obtained from Landsat 8 to capture the maximum defoliation period over winter. The difference in vegetation index (dVI) derived from remote sensing was used as a change detection indicator and was further calibrated with Unmanned Aerial Vehicle (UAV) imagery in the study area. The use of UAVs was incorporated to be the complementary aerial information to the regional forest health surveys for quantifying the defoliation degree at higher temporal and spatial resolution. In regression analysis, the relationships between predicted dVIs and observed defoliation degrees by UAV were compared among five selected dVIs for the coefficient of determination (R^2). Our results showed that the model fitness was highest at 0.081(R^2) using Middle Infrared Wavelengths (MID) or Moisture Stress Index (MSI), which is promising for predicting the severity of defoliation in affected areas where ground-truth data is limited. This study suggests that the UAV technology holds great potential for cost-effectively monitoring the current health of forests. In further studies, combining UAV images with remote sensing data should be considered to validate model predictions of the future forest condition for developing Ecosystem Services tools.