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Mapping and characterising tree mortality in California at individual tree level using deep learning

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Tree mortality caused by natural disturbances, such as droughts, insects, and wildfires, is a global issue due to increased frequency and severity of extreme weather. California has been a major hotspot of large-scale tree mortality since 2012-2015 drought. Despite many local studies, there is no confident count of dead trees at the state level. Here we mapped all individual dead trees in California using submeter aerial images and Convolutional Neural Network (i.e. EfficientUnet architecture). The model accuracy is about 96% and 83% when comparing to visually interpreted samples from aerial photos and in-situ observations, respectively. In total, we found more than 80 million dead trees from NAIP imagery in 2020, which accounts for 2% of trees reported in 2011. About half of the dead trees belongs to California mixed conifer group. North coast and central and southern Sierra Nevada are the most affected regions. Based on the localization and segmentation of every single dead tree, we retrieved mortality traits (i.e. dead tree density, dead crown size, and classification of old or recent death) and identified hotspots that have emerging mortality and high wildfire fuel load. The mortality traits, along with individual dead tree location at the state scale, provides unprecedented detailed information for forest management and improved carbon accounting, helping to understand dynamics and causes of tree mortality in a changing climate.