Forecasting Post-Wildfire Vegetation Recovery in California Using a Convolutional Long Short-Term Memory Tensor Regression Network

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The increasing wildfire frequency and size have posed growing challenges for re-establishing plants after wildfires, making the study of post-wildfire plant regrowth essential for creating effective plans to recover ecosystems. Previous research has predominantly focused on unraveling and analyzing the key ecological and biogeographical factors that influence post-fire succession. This research proposes a novel approach for predicting and analyzing post-fire plant recovery. Using the Normalized Difference Vegetation Index (NDVI) as our metric to quantify vegetation, we develop a Convolutional Long Short-Term Memory Tensor Regression (ConvLSTMTR) network that predicts future NDVI based on short-term plant growth data after fire containment. The model is trained and tested on 104 major wildfires in California from 2013 to 2020 with burn areas larger than 3000 acres. The integration of ConvLSTM with tensor regression enables the calculation of an overall logistic growth rate k using our model's predicted NDVI time series. Overall, our k-value predictions demonstrate impressive performance, with 50% of predictions exhibiting an absolute error of 0.12 or less, and 75% having an error of 0.24 or less. Finally, we employ Uniform Manifold Approximation and Projection (UMAP) and K-nearest neighbor (KNN) clustering to determine trends in similar post-wildfire recovery, providing valuable insight into areas of high and low recovery rates. Our study pioneers the combined use of tensor regression and the ConvLSTM, and introduces the application of UMAP for clustering similar wildfires. Taken together, this study contributes to the advancement of predictive ecological modeling and holds the potential to inform future post-fire vegetation management strategies.