The 2021 Bootleg Fire: A Hydrological Perspective Based on Remotely Sensed Landsat 8 Imagery and Machine Learning Algorithms

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ABSTRACT
The increasing frequency and intensity of wildfires, notably the 2021 Bootleg Fire in Oregon's Fremont-Winema National Forest, underscore a pressing environmental challenge. These wildfires not only alter ecological systems and biodiversity but also significantly impact hydrological cycles by disrupting water balances due to the combustion of organic matter in soil and diminished vegetation vitality.

The objective of this research is to evaluate the hydrological impacts of the Bootleg Fire on soil and vegetation. This research employs a methodological approach that includes classifying land cover and analyzing shifts in the Normalized Difference Vegetation Index (NDVI) to assess vegetation health, alongside the Differenced Normalized Burn Ratio (dNBR) for burn severity assessment. Utilizing Google Earth Engine, the study accessed time-series Landsat 8 surface reflectance imagery, ensuring data accuracy by maintaining a cloud cover threshold below 2%. Comprehensive analysis was performed in Matlab R2023a, leveraging machine learning algorithms such as Support Vector Machine, Decision Trees, and Artificial Neural Networks for classifying the land into distinct categories: Water, Barren, Grassland, Shrubland, Forested Areas, and Densely Forested Areas.

The outcomes of this study illuminate significant transformations within the Fremont-Winema National Forest post-Bootleg Fire. There was a marked increase in shrubland areas and a decrease in grassland and forested areas, signaling shifts in hydrological behavior. Specifically, the study highlights the consequences of landscape changes towards shrubland, including potential disruptions in soil water storage and release mechanisms, altered runoff patterns, and implications for soil moisture levels. Moreover, the variance in burn severity, as indicated by dNBR analysis, suggests diverse hydrological responses across the affected terrain, with areas of higher burn severity facing increased runoff and erosion. These findings not only emphasize the hydrological vulnerabilities associated with fire-affected regions but also highlight the critical need for integrated water resource management strategies in mitigating the impacts of wildfires.