Lightning-Driven Wildfire Risk and Forest Loss in Six Rivers National Forest

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Introduction

Forest ecosystems play a critical role in supporting biodiversity, stabilizing soil, and regulating water, but they are increasingly threatened by wildfires and drought. Humboldt County, California (Figure 1), is especially vulnerable due to its dense redwood forests, high biomass, and dry summers. Dominated by coast redwoods (*Sequoia sempervirens*), Douglas fir (*Pseudotsuga menziesii*), and tanoak (*Notholithocarpus densiflorus*), the region's climate and vegetation contribute to elevated wildfire risk.

This research applies remote sensing and geospatial analysis to identify areas at high risk of forest loss from lightning-induced wildfires. Spatial data reveal strong correlations between lightning strikes, wildfire severity, and forest degradation. Because wildfire impact data often become available only after years, machine learning models offer a timely, predictive alternative. By incorporating wildfire severity, pre-fire conditions such as drought and NDVI, and delayed tree mortality, these models can forecast future forest loss, supporting proactive forest management and improved wildfire mitigation under a changing climate.

Figure 1: Map of the State of California highlighting the location of Humboldt County.

Objective

The primary objective of this research is to analyze geospatial indicators, such as the Palmer Drought Severity Index (PDSI), Normalized Difference Vegetation Index (NDVI), and wildfire occurrence data, to predict forest loss in the Six Rivers National Forest. This analysis will guide the development of a machine learning model to quantify forest cover change, identify high-risk areas, and support data-driven forest management decisions.

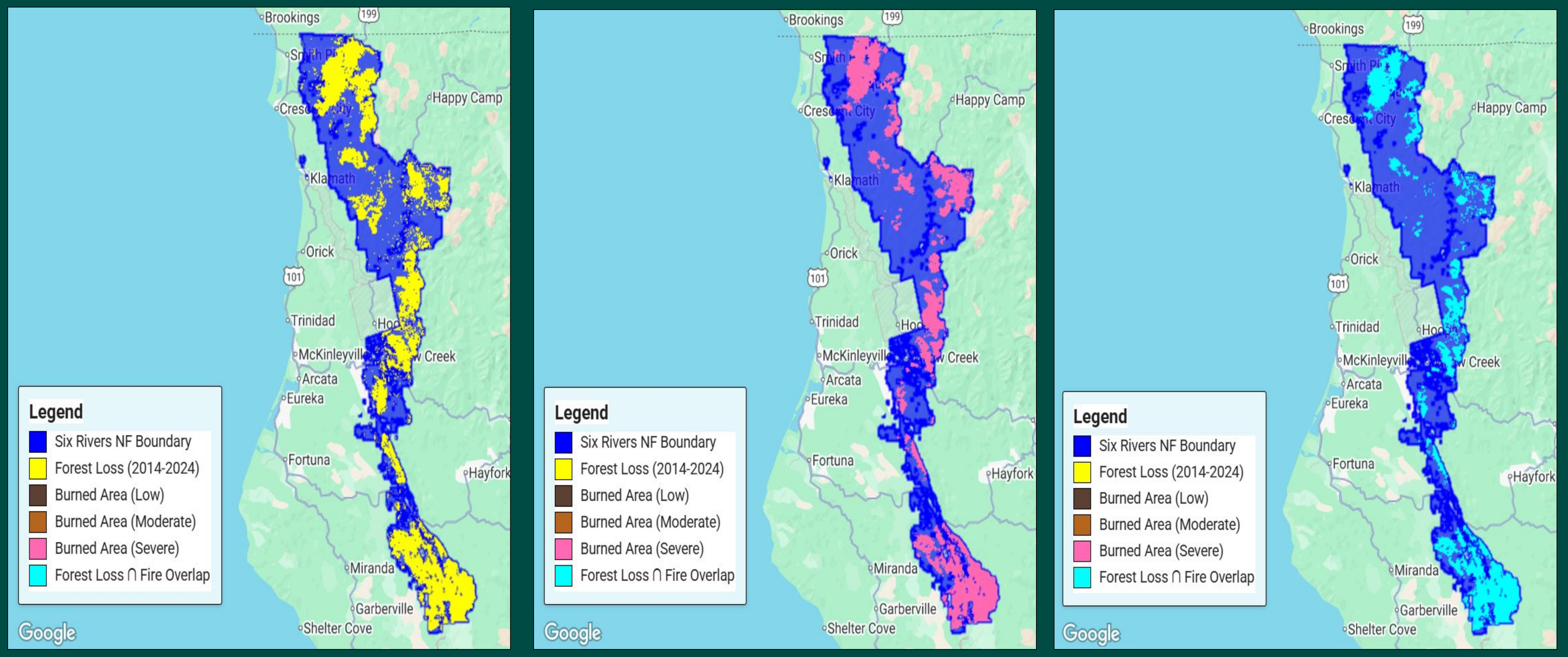

Figure 2. (Left): Forest loss in Six Rivers from Hansen data. (Center): Wildfire severity from MODIS burned area. (Right): Overlap of forest loss and wildfire severity.

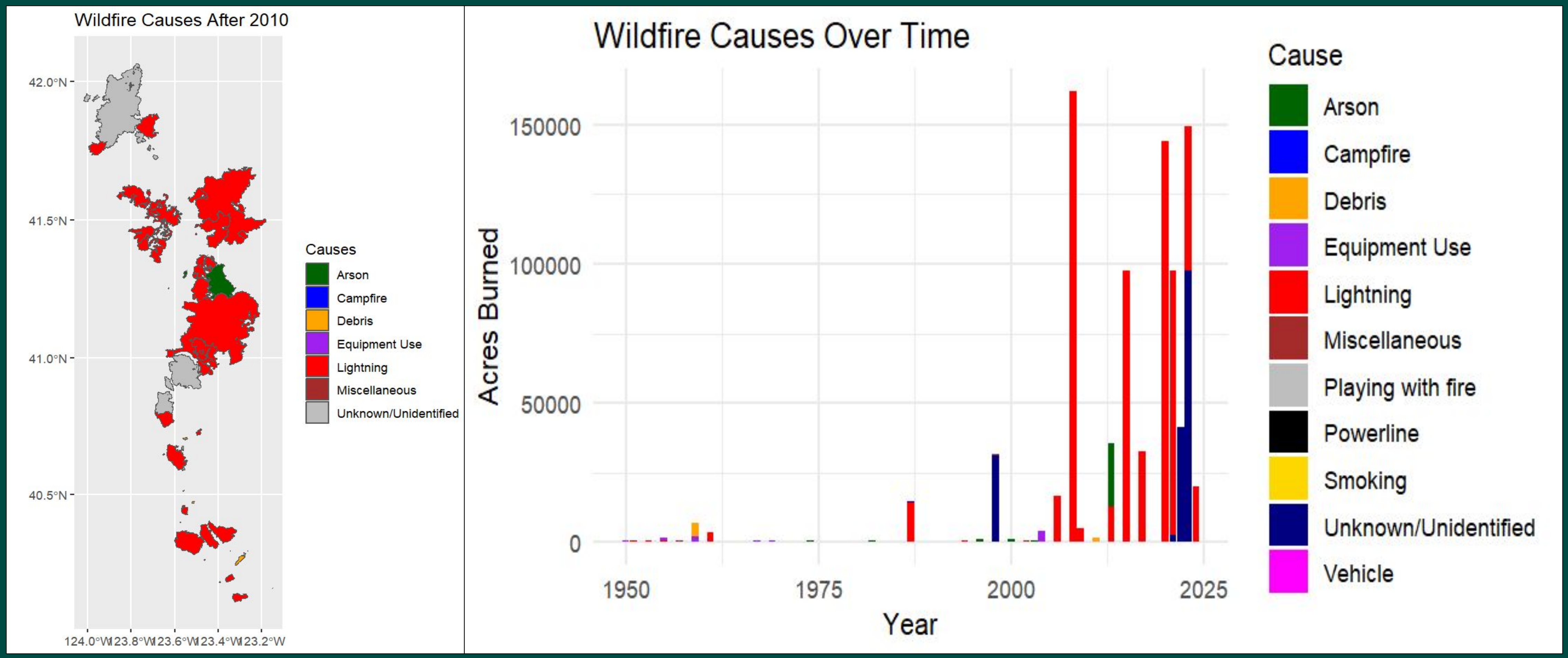

Figure 3. (Left): Wildfire ignition sources in Six Rivers National Forest since 2010, based on CAL FIRE Perimeter data, highlighting spatial distribution by cause. (Right): Temporal trends in wildfire causes, showing a rise in lightning-related fires after 2000, indicating a significant shift in ignition patterns over time.

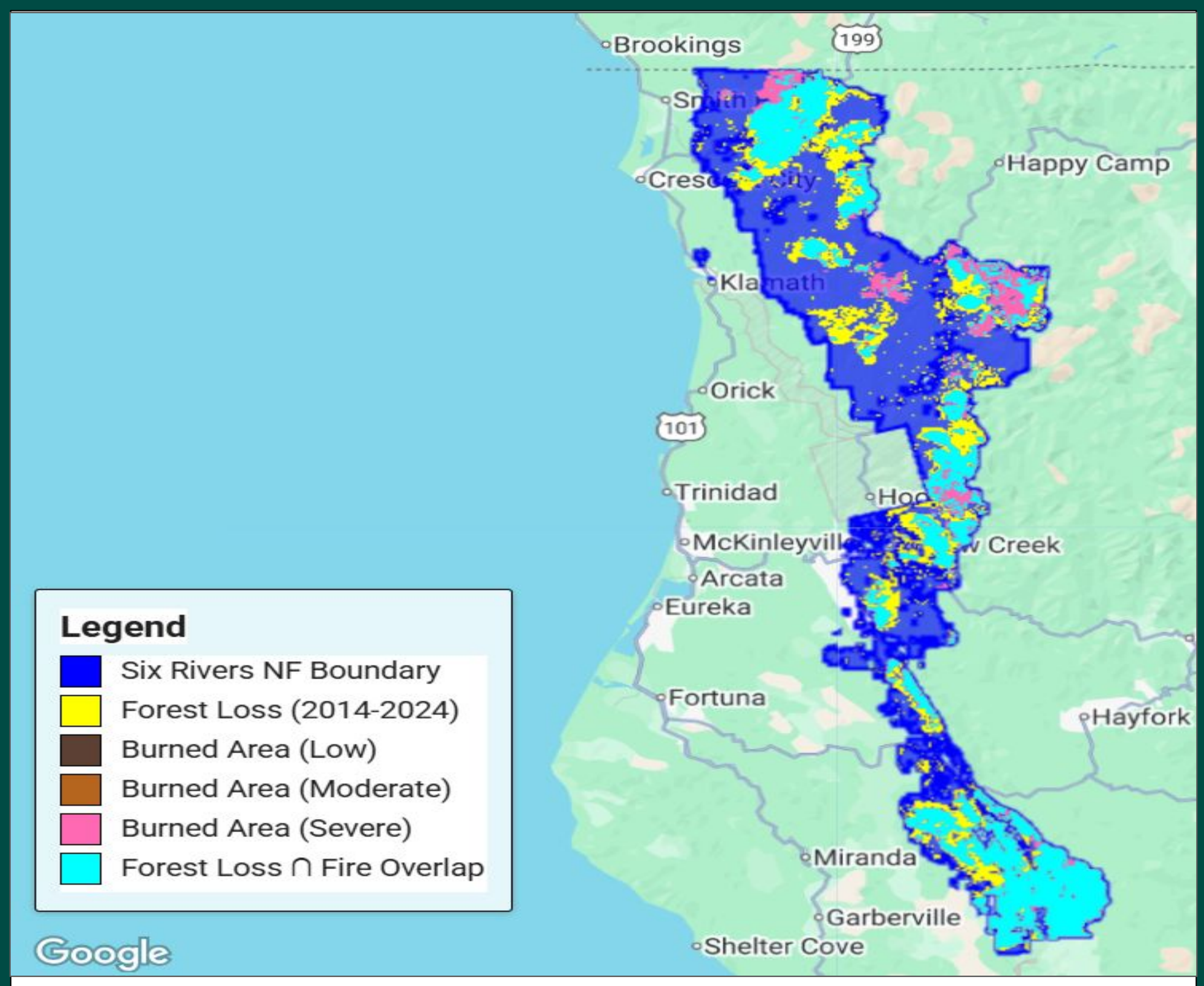

Figure 4. (Top): Builds on earlier maps of forest loss (Hansen), wildfire severity (MODIS), and their spatial overlap in Six Rivers.

Results

Spatial analysis reveals strong overlap between forest loss and areas of high wildfire severity within Six Rivers National Forest. Hansen forest loss data aligns closely with MODIS burned area severity, indicating wildfire as a major driver of forest degradation. CAL FIRE ignition data show a pronounced shift in wildfire causation after 2000, with lightning emerging as the dominant ignition source. This transition suggests increasing climate-driven influences on forest loss dynamics.

Next Steps

Future work will apply unsupervised machine learning to NDVI, PDSI, wildfire occurrence, ignition source data, and forest loss to identify spatial patterns and clusters of lightning-driven wildfire risk, supporting proactive, data-driven forest management.

Methods

Moderate Resolution Imaging Spectroradiomter (MODIS)

Provides vegetation health indices such as NDVI and EVI at spatial resolutions ranging from 250 meters to 1 kilometer, allowing consistent long-term vegetation monitoring

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Landsat 8 Operational Land Imager (OLI)

Captures multispectral imagery at 30-meter resolution, enabling detailed monitoring of forest cover change, drought stress, and post-fire vegetation recovery

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California Fire Perimeters (1950+)

Maintained by CAL FIRE's Fire and Resource Assessment Program (FRAP), this dataset maps wildfire perimeters across California from 1950 to 2025,

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Citations

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