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# Wildfire Damage Assessment over Eaton Canyon, California, using Radar and Multispectral datasets from Sentinel Satellites and Machine Learning Methods

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## INTRODUCTION & AIM

Wildfires are a pervasive natural hazard, especially in regions with a Mediterranean climate like Southern California. The Eaton Canyon region, nestled in the San Gabriel Mountains, is highly susceptible to wildfires due to its chaparral and scrub vegetation, steep topography, and proximity to urban areas. Assessing the extent and severity of wildfire damage is essential for various post-fire activities, including ecological restoration, hazard mitigation, and insurance claims.

The advent of satellite remote sensing has revolutionized the ability to monitor and assess environmental changes, including those caused by wildfires. Sentinel satellites, part of the European Union's Copernicus program, provide a wealth of freely available, high-resolution data that are particularly well-suited to wildfire studies.

Our study employs an approach integrating satellite imagery from the European Space Agency's Sentinel constellation to survey an area of 271.49 $km^2$ to create a wildfire severity map. The data encompasses both radar and multispectral data, offering a multi-dimensional view of the affected landscape.

When performing the work, the following tasks were set:

- Analysis of Sentinel Satellites Characteristics;
- Analysis and comparison of wildfire indices;
- Development of machine learning algorithm to create a fire severity map using wildfire indices independently based on their accuracy and Kappa Index;
- Development of a proposal fusion approach to create a precise fire severity map;
- Analysis of NASA predictions and comparison with the results obtained within the framework of the proposed approach;

Sentinel satellites images of wildfire in Eaton Canyon, California

Unmanned Aerial Vehicles images of wildfire in Eaton Canyon, California

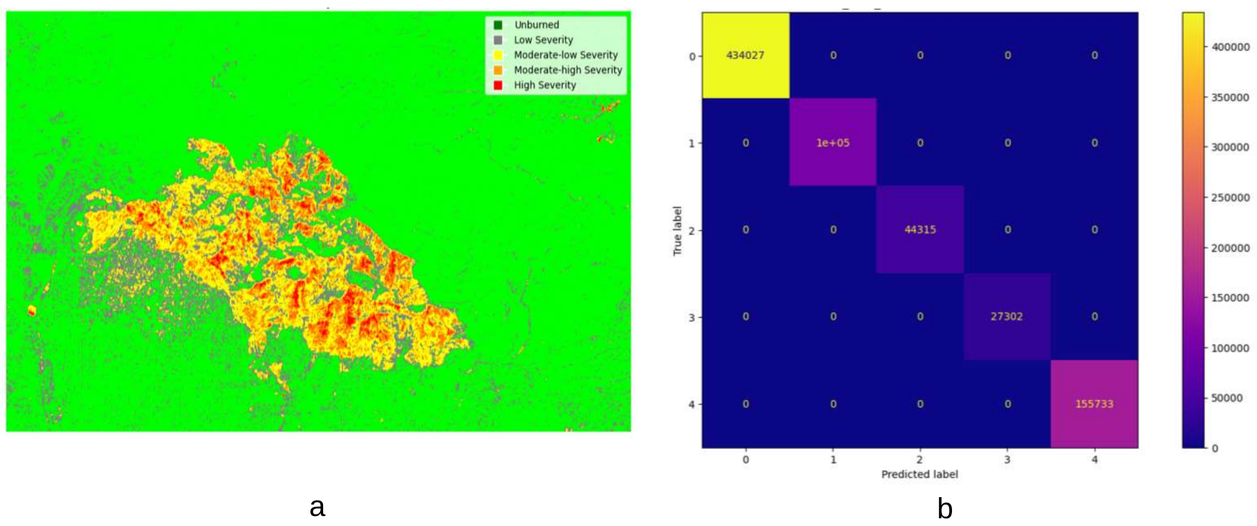
## METHOD

The analysis leverages the power of the Random Forest Algorithm. We used five fire severity classes, including: Unburned, Low Severity, Moderate-Low Severity, Moderate-High Severity, High Severity. To create a fusion approach to create a precise map of fire severity, we combined Difference Normalized Burn Ratio (DNBR), Relative Burn Ratio (RBR), and Relative Difference Normalized Burn Ratio (RDNBR). The process begins with data acquisition and pre-processing. This typically involves obtaining pre- and post-fire satellite imagery such as Sentinel-1 and Sentinel-2, due to their suitable spatial and spectral resolutions for burn severity mapping.

Merging these three indices (DNBR, RBR, RDNBR) within a random forest offers several advantages. By combining them, the Random Forest Algorithm can exploit the unique information content of each index, allowing for a more comprehensive and accurate assessment of fire severity than with a single index.

## RESULTS & DISCUSSION

The results showed a perfect 100% accuracy and Kappa Index in all the predictions. A percentage of 56.79% did not burn, due to the topography of the canyon creating natural firebreaks. Areas classified as low severity (13.49%) showed minimal damage with minimal tree mortality. Moderate- to low-severity areas (5.79%) represented regions with partial crown burn and some tree mortality. Moderate- to high-severity areas (3.57%) showed significant tree mortality. Finally, high-severity areas (20.36%), characterized by complete tree mortality and significant loss of vegetation cover, were largely concentrated in specific sections of the canyon, likely influenced by factors such as slope and fuel type. These findings provide valuable information for post-fire ecological recovery efforts and future land management strategies in Eaton Canyon and similar fire-prone landscapes.

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Fire severity classification map results: (a) Classification map, (b) Confusion Matrice

## CONCLUSION

The results of the Eaton Canyon wildfire provide valuable information for post-fire ecological recovery efforts and the development of more effective land management strategies in Eaton Canyon and other fire-prone landscapes. Accurate mapping of burn severity allows for targeted restoration, focusing resources on areas with the greatest ecological damage. Understanding the influence of topography and fuel types on fire behavior, as demonstrated by unburned and high-severity areas, can inform proactive measures such as strategic fuel reduction and the creation of defensible spaces.

## FUTURE WORK / REFERENCES

Our future work focuses on the classification and distribution of vegetation types before and after wildfires using deep learning methods extended to other regions.

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