National Aeronautics and Space Administration

FY25 Strategic University Research Partnership (SURP)

Quantifying functional stability of California ecosystems using imaging spectroscopy after a decade of drought and fire

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Background: This project is quantifying ecosystem responses to disturbance across California. Results from this project will inform the sensitivity, stability of terrestrial ecosystems' carbon storage, biodiversity to climate change.

Objectives:

1. Characterize post-fire vegetation recovery across an environmental and ecological gradient in southern California,
2. Estimate plant traits using imaging spectroscopy, and test the transferability of trait mapping models across sites & years,
3. Analyze plant trait variability in space and time in relation to disturbance regimes and vegetation types.

Approach and Results (Year 3)

Objective 1: We have created fire recovery maps for all California wildfires reported by MTBS between 2001-2020 (Fig. 1). Vegetation recovery was calculated as time until a burned pixel's NDVI time series was comparable to nearby, unburned, matched pixels (Fig. 2).

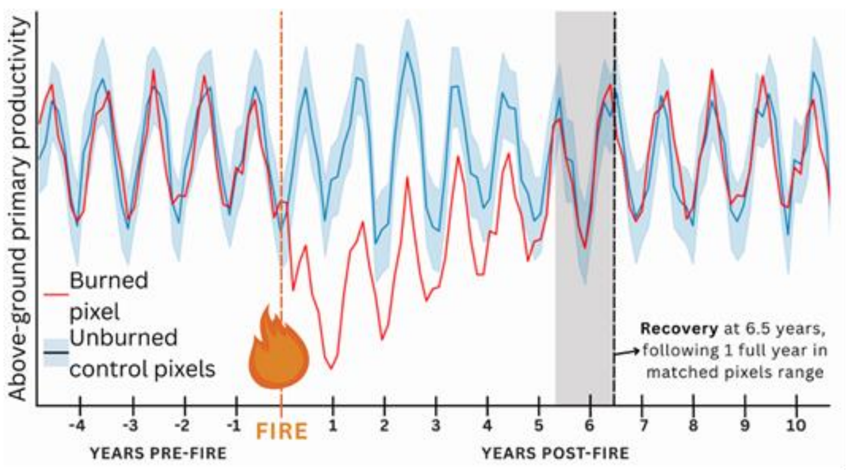

Figure 2. Graphical depiction of recovery time calculation for hypothetical data. Aboveground primary productivity time series is shown in red for a single burned pixel. Recovery time is calculated as the time it takes for the burned pixel to match the productivity pattern (+/- 1 standard deviation) for all nearby, matched unburned pixels for one full year. Nearby pixels are matched on vegetation type, elevation bands, and pre-fire productivity.

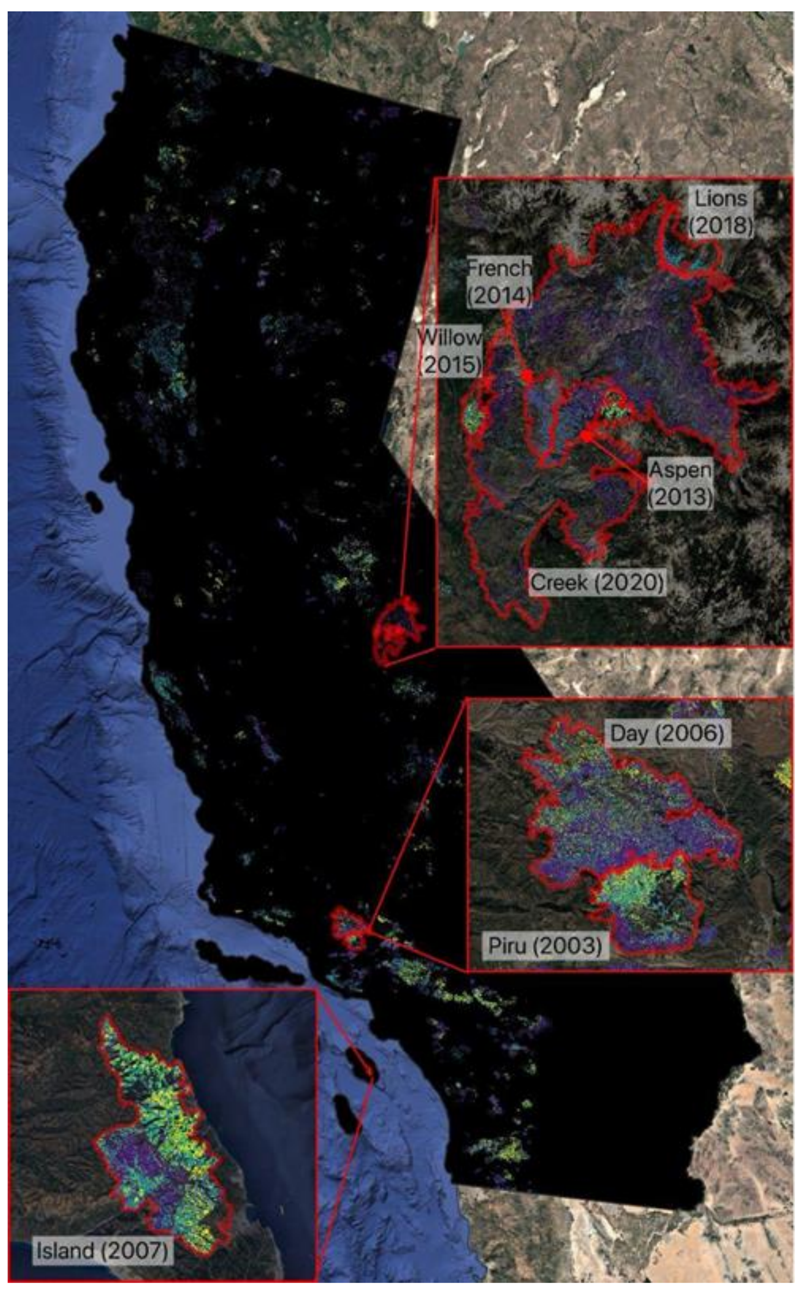

Figure 1. Map of recovery times for 922 fires analyzed in California from 2001 to 2020 at 30m resolution. Pixels were masked if there was insufficient temporal Landsat coverage in the ten years post-fire, if there were too few matched undisturbed pixels, or if the pixel was recorded as experiencing any additional post-fire disturbance.

We are analyzing the results from the recovery maps to understand drivers of recovery time, with a focus on the impact of post-fire climate conditions - particularly drought and hot drought - on vegetation recovery rates across widely varying ecosystems. We are finding that hot drought amplifies the impact of either drought or high temperatures alone (Fig. 3b).

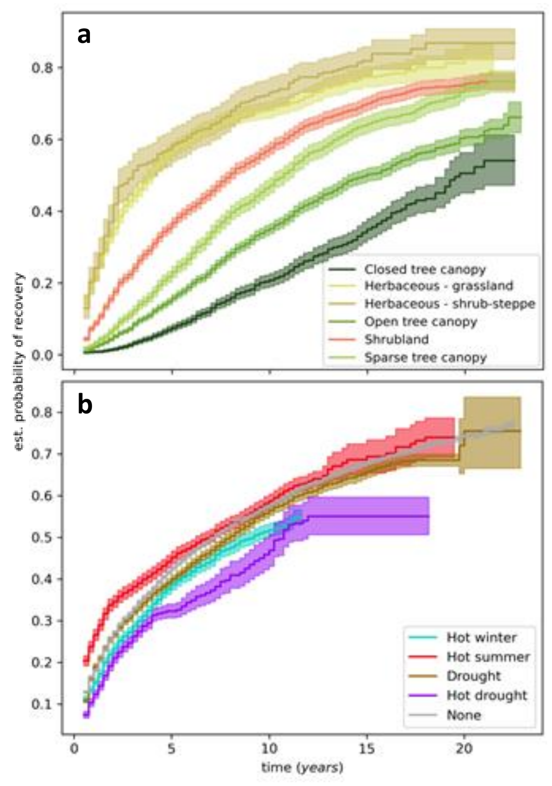

Figure 3. Kaplan-Meier curves for sampled pixels (N=57,938). Recovery curves were calculated for pixels binned by (a) pre-fire vegetation type and (b) 1-year post-fire climate conditions. 95% confidence intervals were calculated using the log hazard.

Next steps: We will finalize the random survival forest models to identify drivers (climate, disturbance history, ecosystem characteristics) of vegetation recovery trajectories.

Objective 2: During the 2023 and 2024 field seasons, we collected over 500 canopy foliar trait samples across three NEON sites concurrent with NEON AOP flights, bringing together a field team across a wide range of career stages and institutions. All 2023 trait samples have been processed. 2024 samples are currently being processed by external labs.

Next steps: Finish development of trait maps over three NEON sites for comparison with SHIFT and Western Diversity Time Series (WDTS) trait maps.

Figure 4. Our field team included high school, undergrad, & grad students, postdocs, and faculty from a range of institutions, including UCLA, LBNL, USC, and UM.

Objective 3: Building on work from Objectives 1 and 2, we are assessing the relationship between plant functional diversity and post-fire recovery trajectories. We assessed the relationship between fire recovery across the state of California (Fig. 2), and plant functional richness (FRic) using trait data from the Western Diversity Time Series (Fig. 5, Zheng et al. 2025). Thus far, we have not found significant differences in recovery time by pre-fire FRic (Fig. 6), but have only tested our analyses on a subset of fires, and have not yet controlled for other drivers of recovery time. **Next steps:** After completing Obj. 1 models, we will test if adding FRic improves model predictions of recovery trajectories.

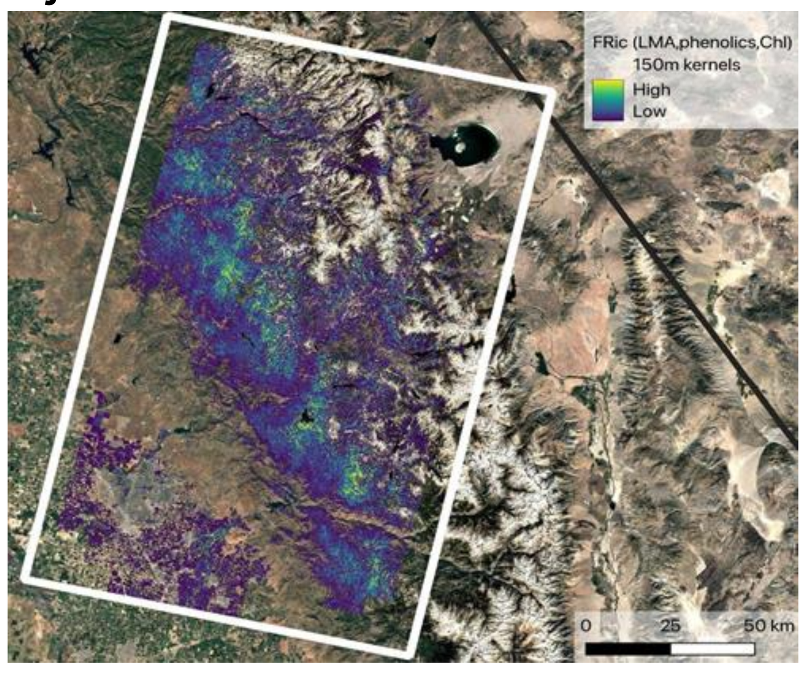

Figure 5. Functional richness (FRic) map using LMA, phenolics, Chl trait maps from the WDTS. FRic was calculated as the convex hull volume of scaled trait values with a 150m kernel size (Schneider et al. 2017).

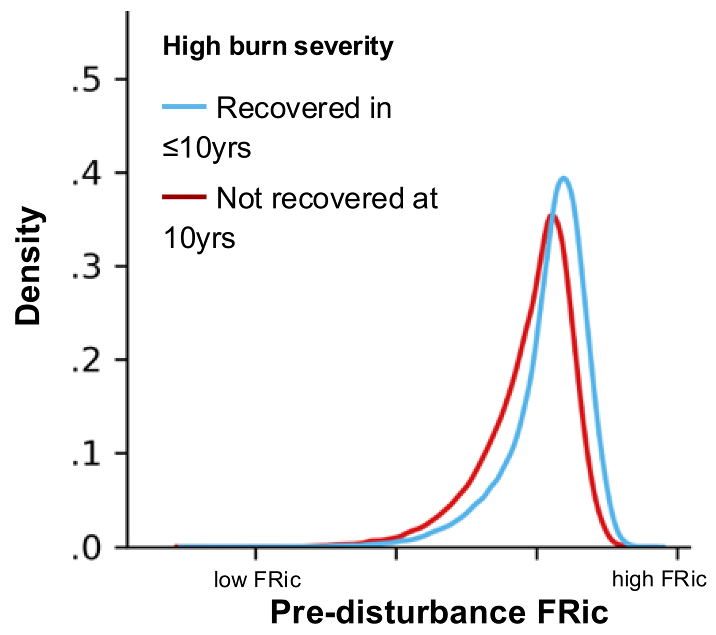

Figure 6. Kernel density estimate of pre-disturbance FRic (Fig. 5) for pixels burned at high severity that recovered within 10 years (blue) and did not recover within 10 years (red), aggregated over 16 fires.

Significance/Benefits to JPL and NASA:

- Provide early use cases for data and workflows as they will become available from JPL-led EMIT and SBG missions.
- Utilize the SHIFT and NEON data to study the relationships between biodiversity and ecosystem stability following fire and drought in California ecosystems.

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