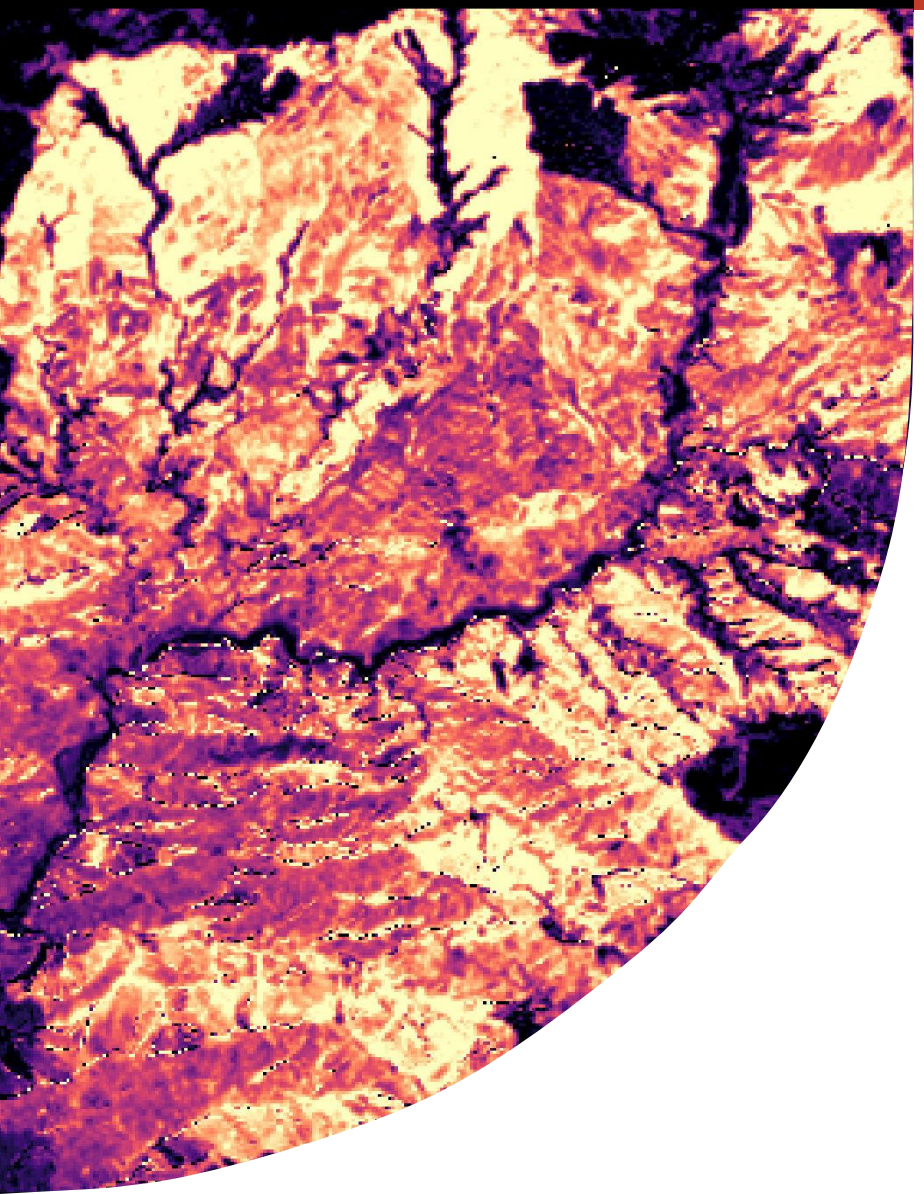
National Aeronautics and Space Administration



San Bernardino Wildland Fires

Assessing the Conditions of Pre-Fire and Post-Fire Vegetation in San Bernardino California with NASA Earth Observations

Sofia Ingersoll, Samea Derrick, Shilpa Kannan, Darcy Tate(Analytical Mechanics Associates)

California – JPL | Spring 2025

Meet the Team

Sofia Ingersoll
(Project Lead)

Samea Derrick

Shilpa Kannan

Darcy Tate

Natural Case Study

We aim to support the idea that prescribed fires can be **beneficial** for forest and ecosystem health.

Prescribed burn near the Clear Creek fire station in the Angeles National Forest, 2020. Image Credit: USDA Forest Service

Background

Image Credit: USDA Forest Service

Wildland fires can:

- **Devastate** landscapes
- **Destroy** structures, roads, and farmland
- **Displace** entire communities

Prescribed burns are controlled fires that are intentionally created to remove fuel.

Prescribed "Rx" burns can:

- **Reduce** fuel accumulation
- **Improve** ecosystem health
- **Prevent** large-scale burns

Our Partners

Image Credit: Climate Hubs U.S. Department of Agriculture

USDA Forest Service Wildland Fire Management Research & Development (R&D)

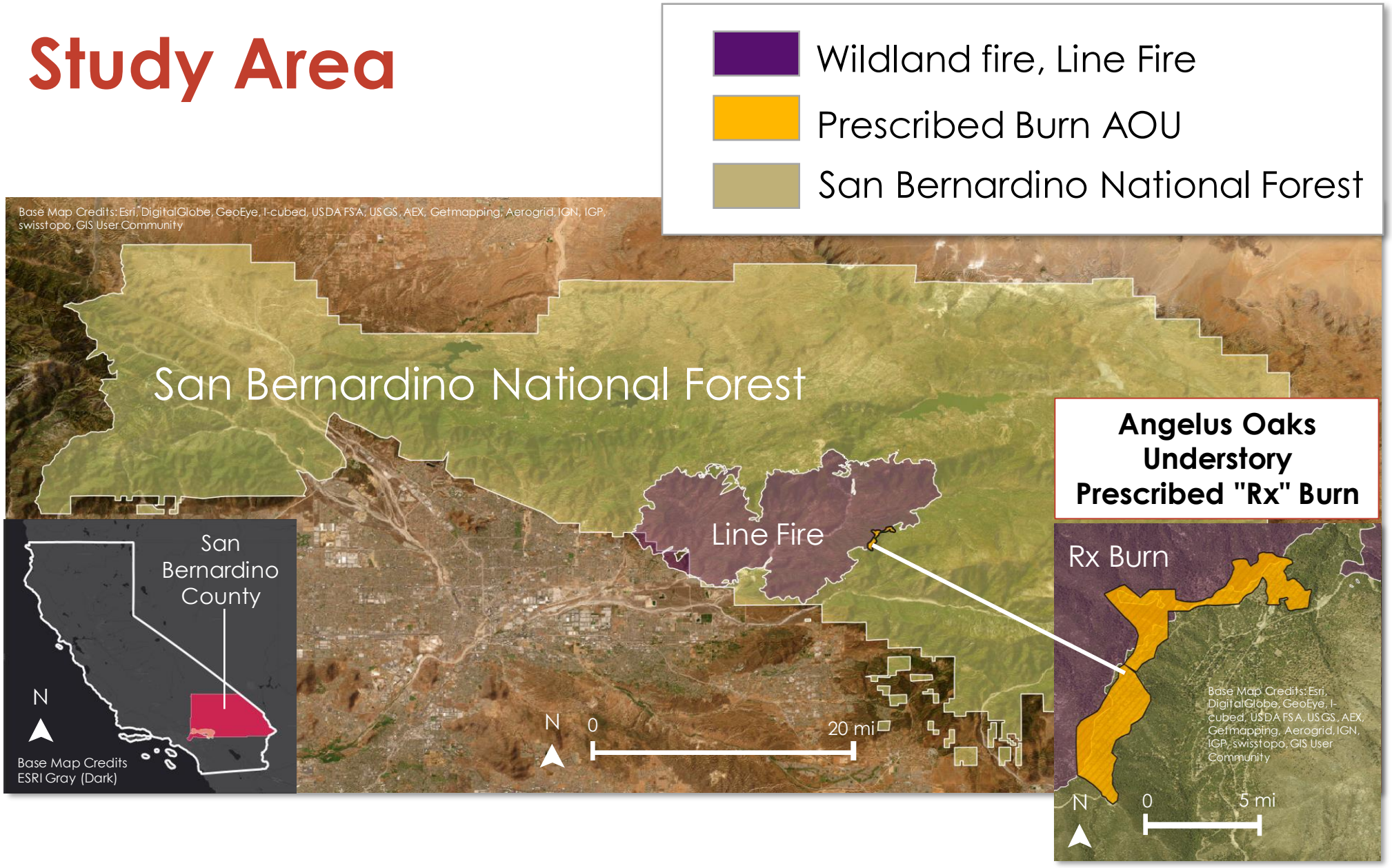
USDA Forest Service San Bernardino National Forest

San Bernardino Valley Municipal Water District

California State University (CSU) San Bernardino, Institute for Watershed Resiliency

California State University (CSU) Northridge, Center for Geospatial Science & Technology

Study Area



Study Area
San Bernardino National Forest

Case Studies

Line Fire (2024)

Angelus Oak Understory Rx Burn (2024)

Community Concerns

Image Credit: USDA Forest Service

Wildfire Risk
Frequency & Intensity

Image Credit: USDA Forest Service

Increased Risk of
Displacement for Residents

Image Credit: USDA Forest Service

Proactive Land
Management Practices

Objectives

We sought to:

Identify Vegetation Water Use Trends

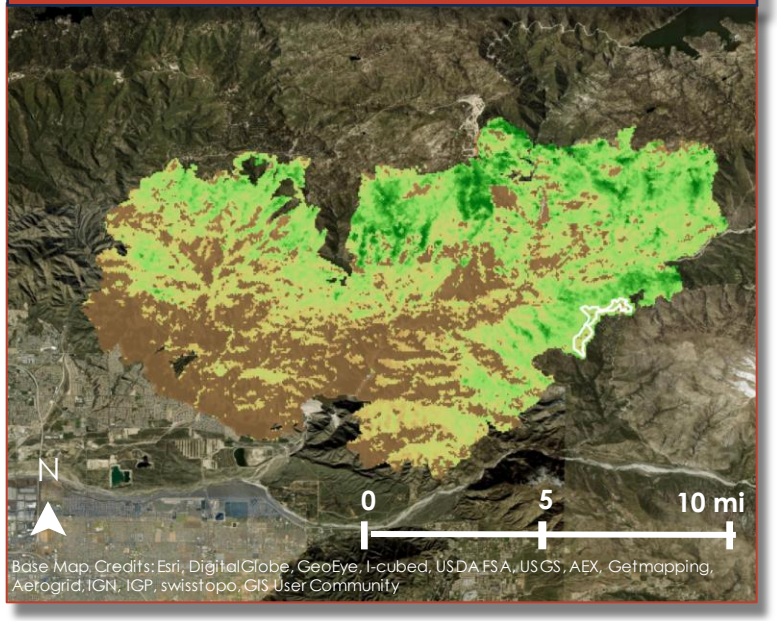


Image Credit: HLSL-30 (2024)

Understand Fire-Fuel Load Recovery Rates Over Time

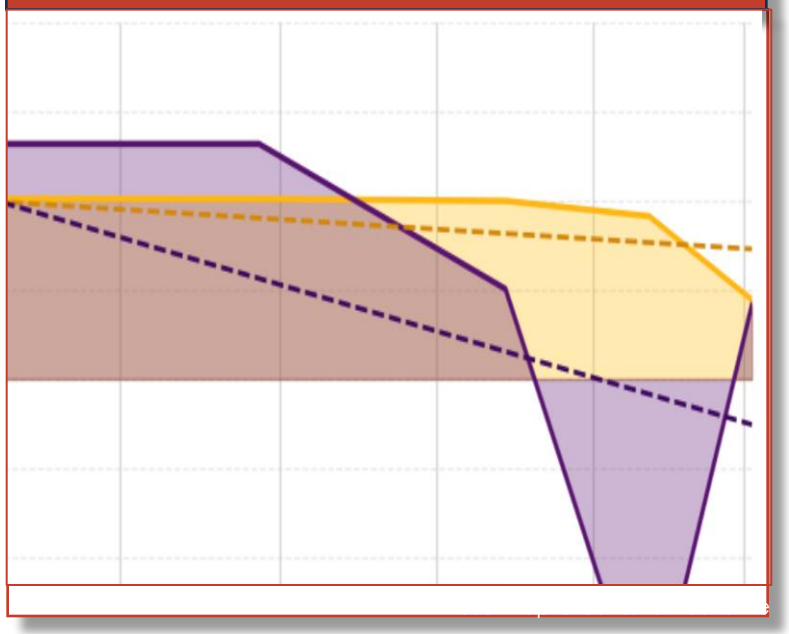


Image Credit: HLSL-30 (2023-2025)

Characterize Prescribed & Wildfire Soil Burn Severity

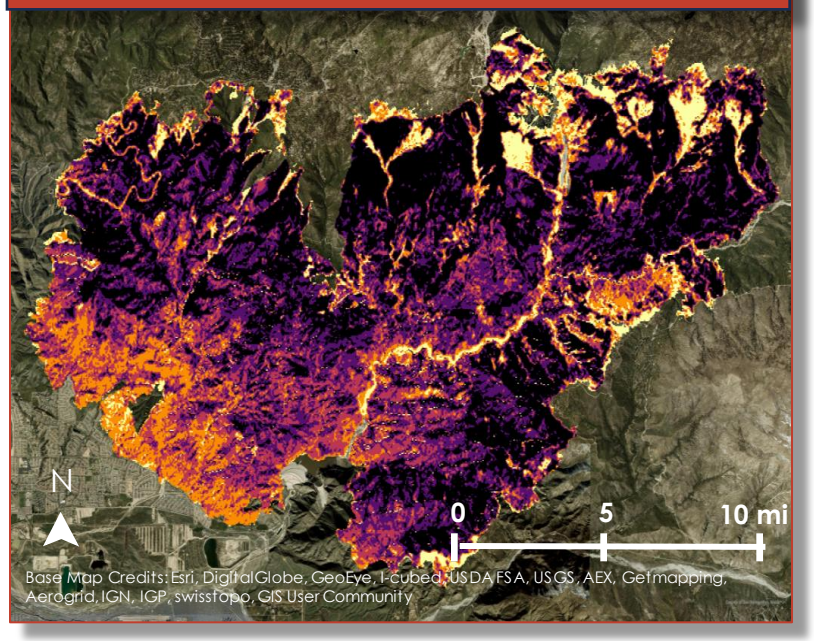
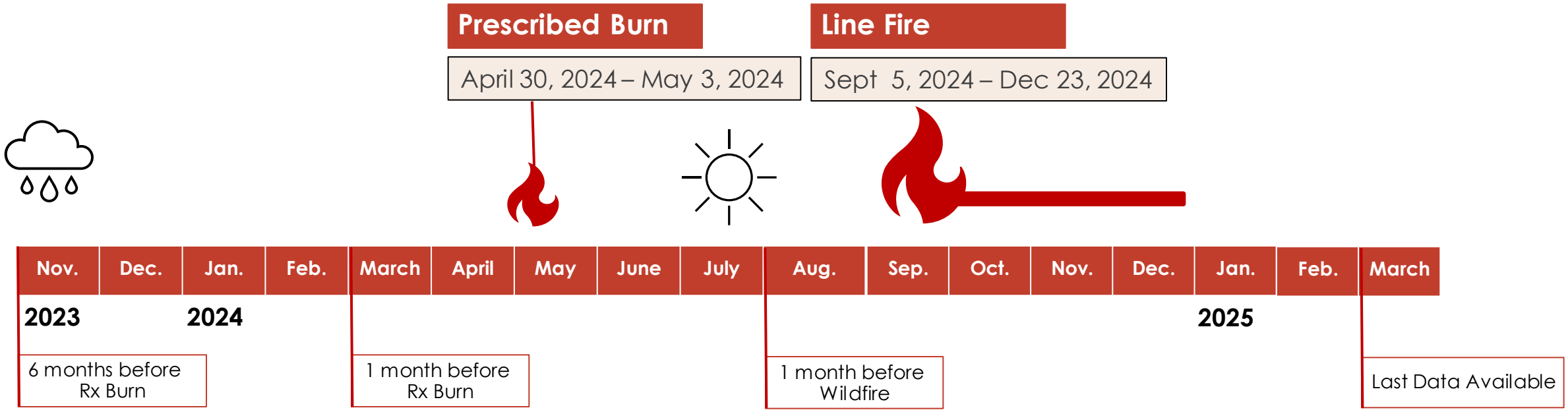


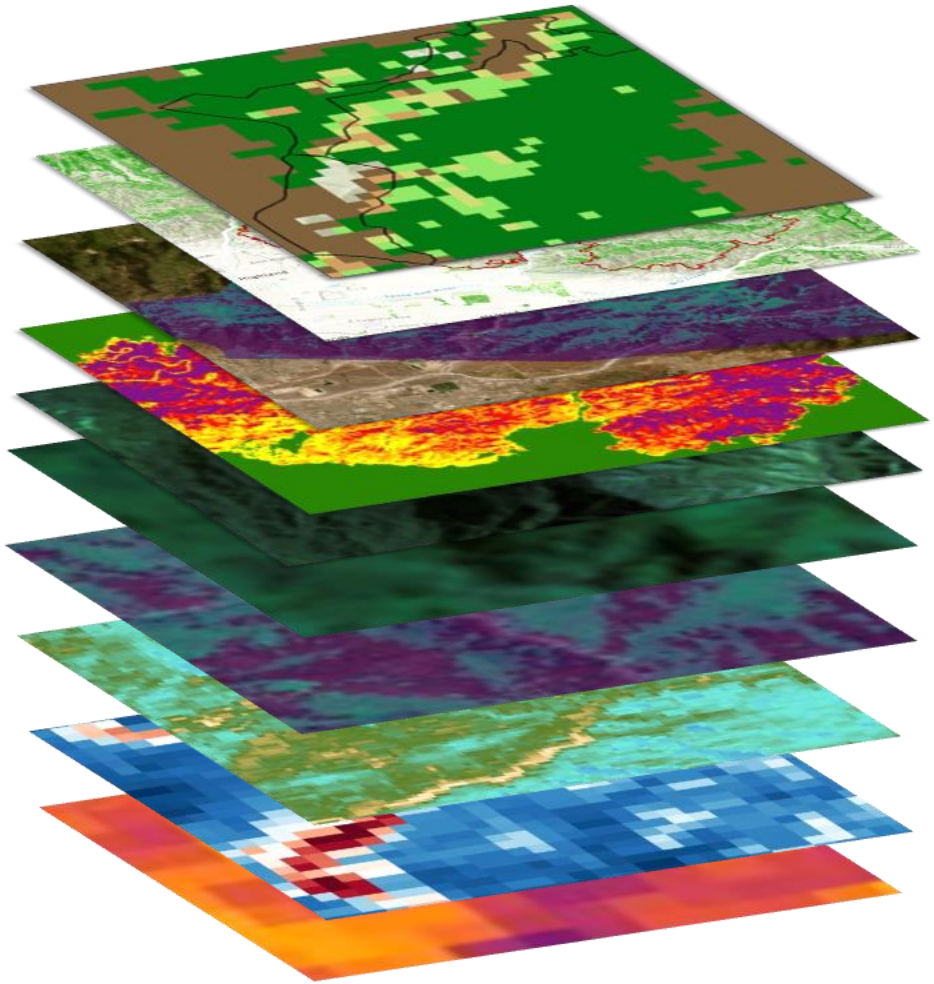
Image Credit: EMIT (2023)

Study Period



Earth Observations

Methodology: Environmental Variables



- Topography
  - Slope
  - Elevation
  - Aspect
- Soil Moisture
- Evapotranspiration
- Enhanced Vegetation Index
- LANDFIRE
- Evaporative Stress Index
- Difference Normalized Burn Ratio
- Soil Burn Severity
- Canopy Water Content
- Pre-fire Fuel Load & Fuel Load Proxy

Methodology: Comparing Fire Landscape Characteristics

VEGETATION ASSESSMENT

Calculate natural environment indices using NASA satellite and radar data

FIT TO FIRE FOOTPRINT

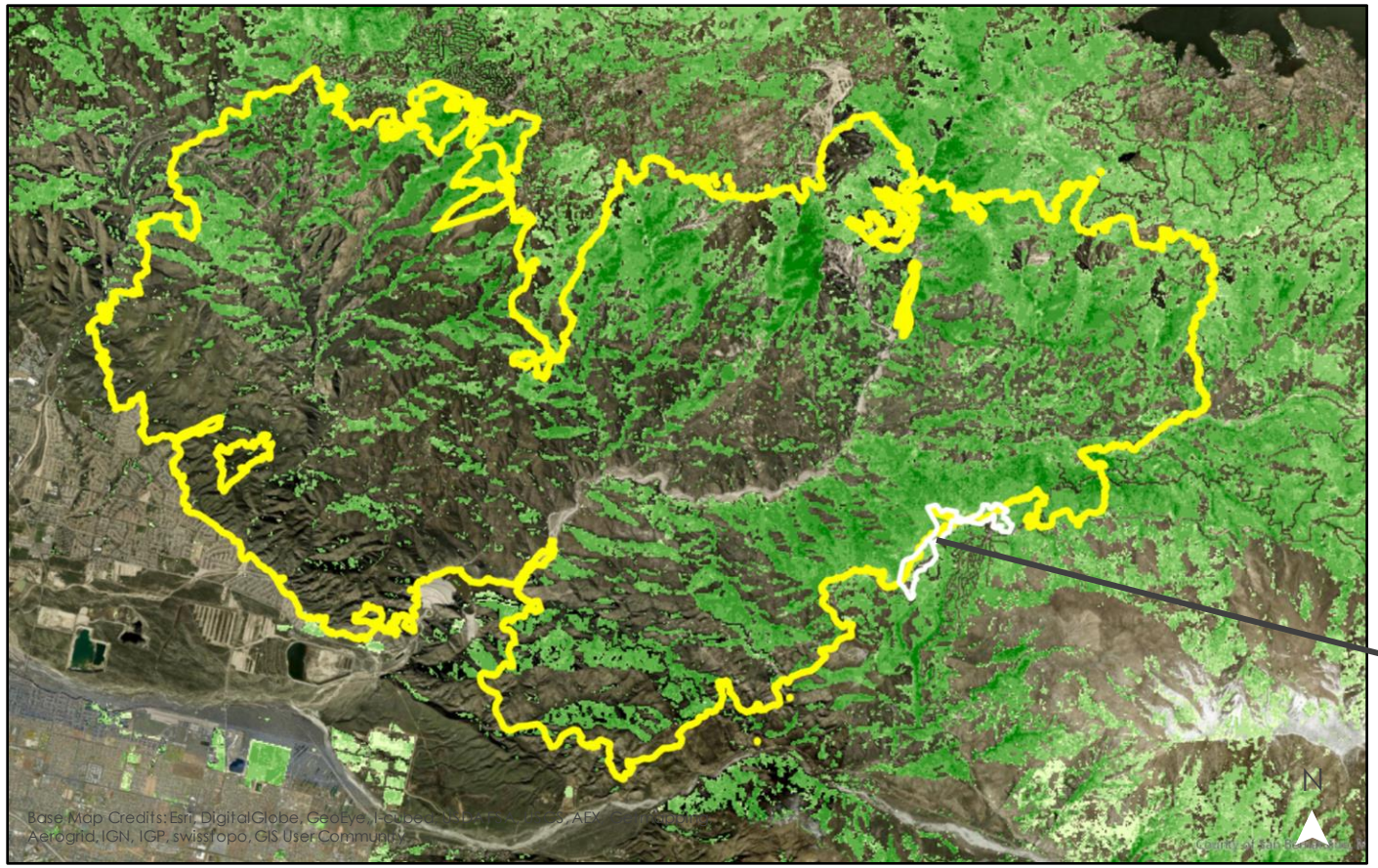
Mosaic tiles to collect specific points in the event timeline.
Clip indices calculations using perimeters specific to each fire in Python & ArcGIS Pro

COMPARE & QUANTIFY DIFFERENCES IN INDICES

Compute vegetation indices **time series comparisons**, **OLS regression analysis**, and **classify landscape burn severity for each fire**

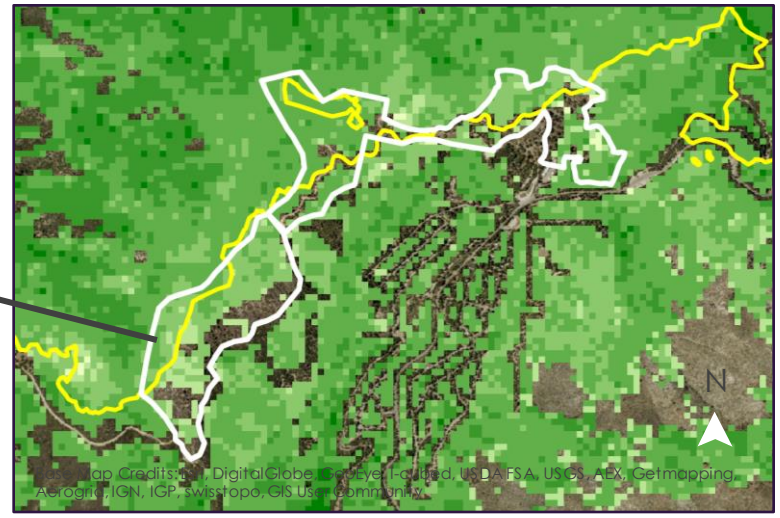
Results: Existing Tree Cover Percentages

2023 Pre-Fire Tree Cover



Tree Cover Percentages

- 10-20%
- 20-30%
- 30-40%
- 40-50%
- 50-60%
- 60-70%
- 70-80%
- 80-90%
- 90-100%

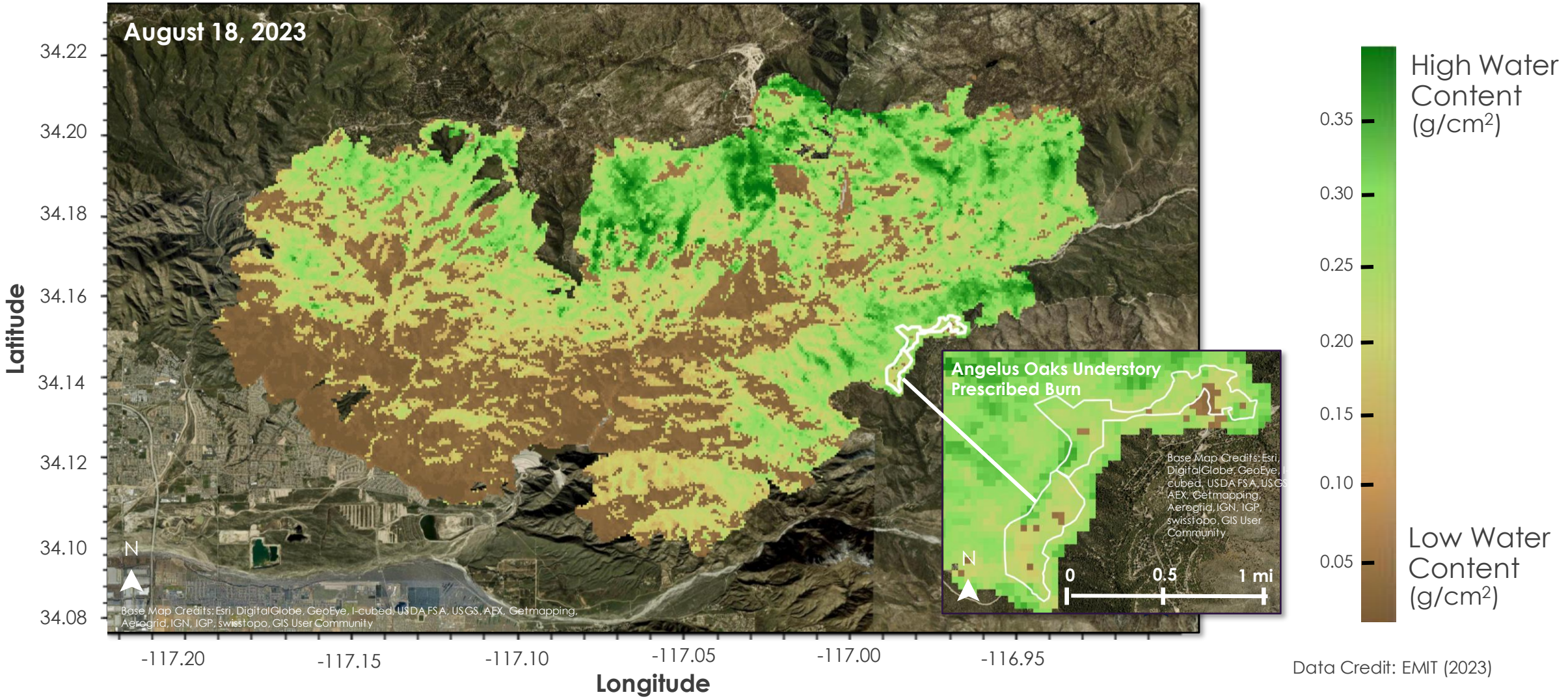


Line Fire

Angelus Oaks Understory Prescribed Burn

Data Credit: EMIT (2023)

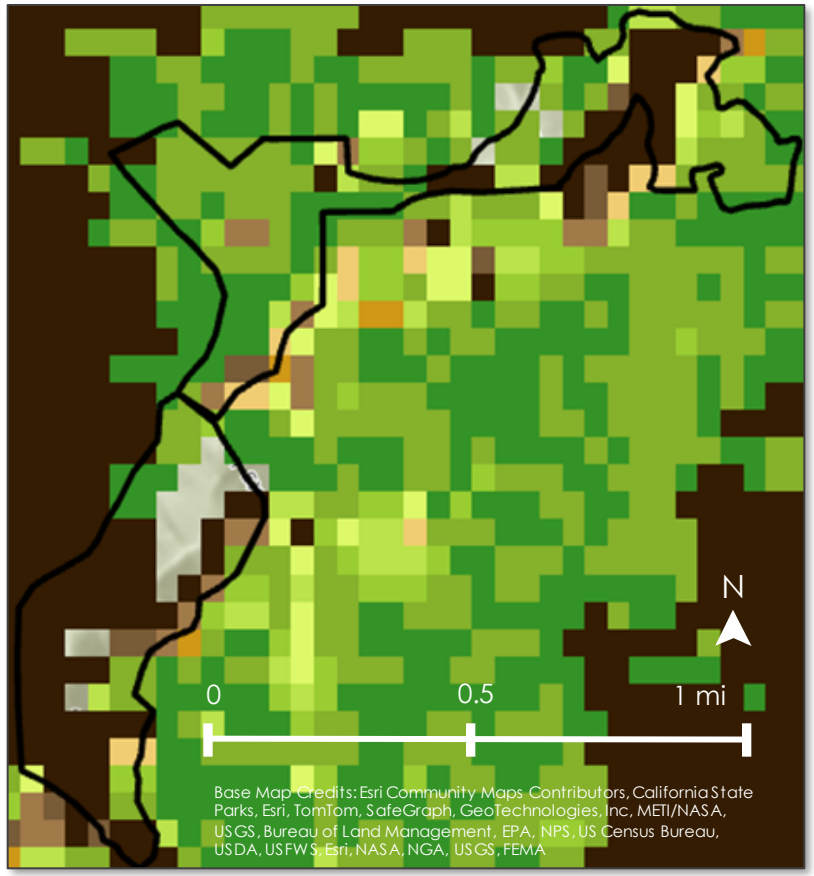
Results: Measuring Canopy Water Content



Data Credit: EMIT (2023)

Results: Evaporative Stress Index Example

ESI 3 months Before Prescribed Fire February 13, 2024



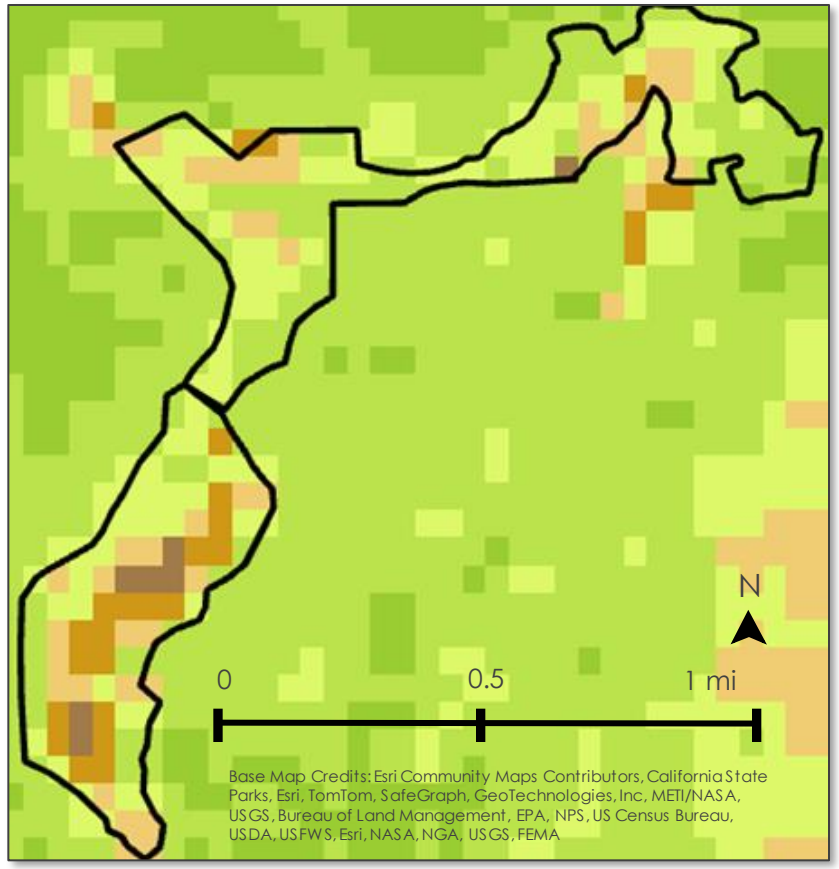
AOU

1 Low Water Stress

0 High Water Stress

AOU Fire Perimeter

ESI 3 months After Prescribed Fire August 3, 2024 – Sep 30, 2024



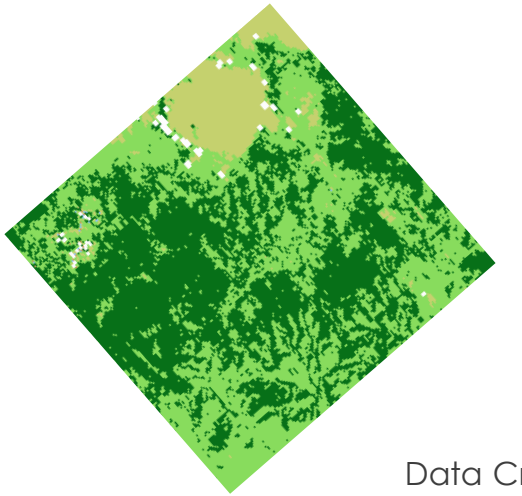
Results: NDVI Landscape Greenness Trends

Line Fire

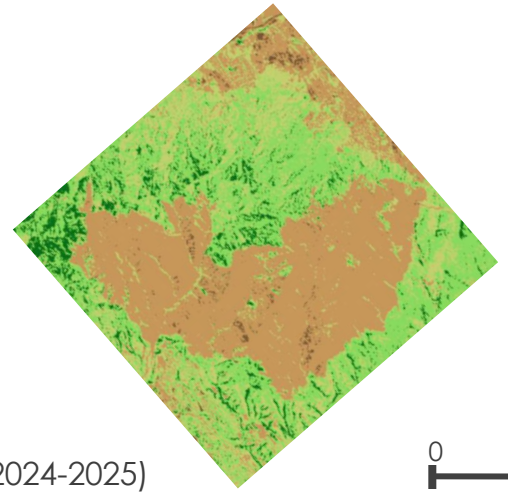
(September 5 – December 21, 2024)

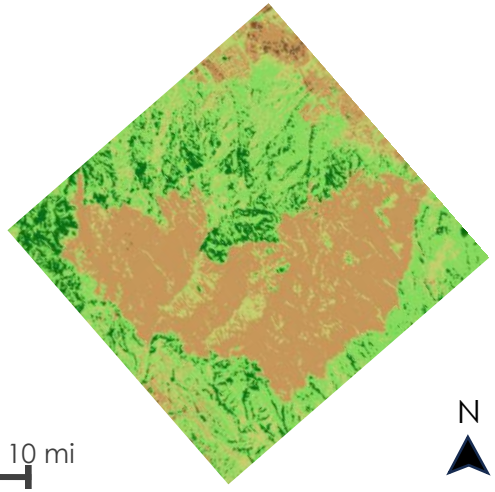
Our investigation revealed a **dramatic change in vegetation greenness caused by the Line Fire**. Normalized Difference Vegetative Index (NDVI) revealed the vegetation health by quantifying the amount of green is in plants.

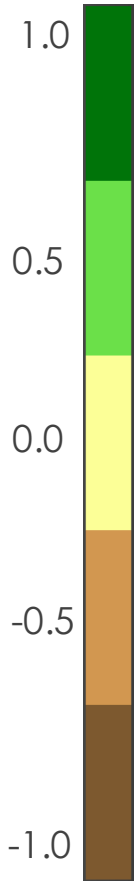
Aug 1, 2024	Jan 23, 2025	Feb 22 & March 4, 2025
1 Month Before	1 Month After	3 Months After



Wildfire







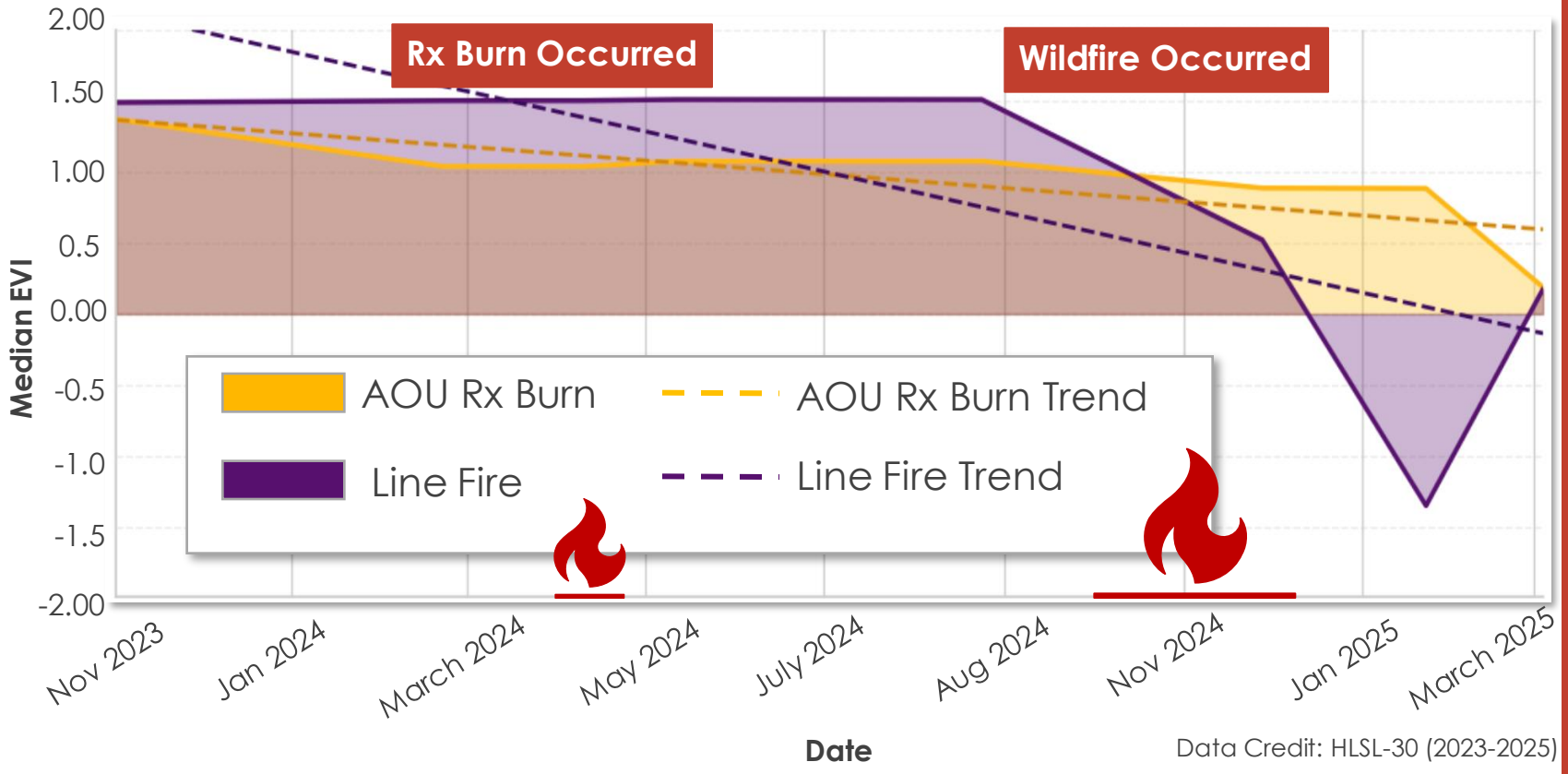
Data Credit: HLSL-30 (2024-2025)

0 5 10 mi

N

Results: EVI
Landscape Greenness Trends Overtime

EVI Time Series OLS Regression Analysis:
Angelus Oaks Understory Prescribed Burn vs Line Fire
(Nov 2023 – March 2025)



Data Credit: HLSL-30 (2023-2025)

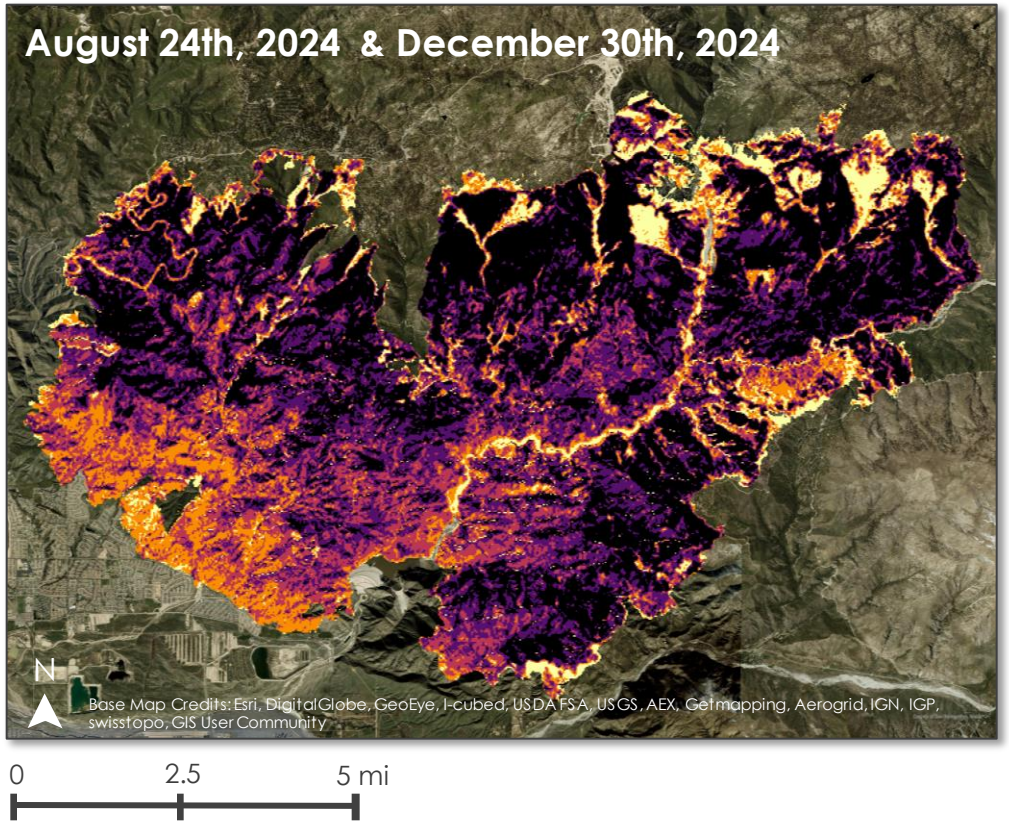
Understanding Dense Canopy Recovery Rates

- **Significant decreasing trends for both** the AOU Rx Burn and the Line Fire were identified for EVI
- Comparing the two, the **Line Fire has a greater rate of canopy greenness loss overtime**

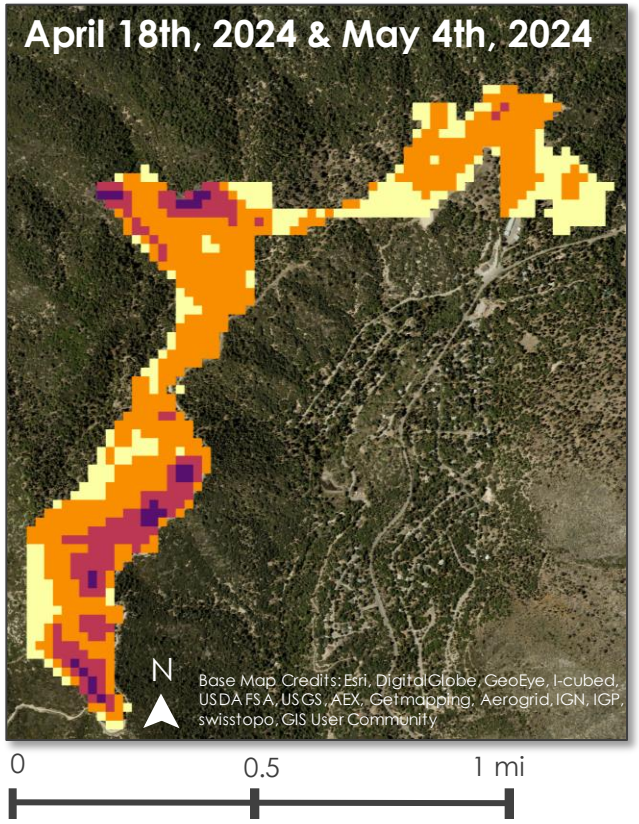
Note: this model does not include interactive variables and is subject to omitted variable bias. Significance threshold ($p < 0.05$)**

Results: Differenced Normalized Burn Ratio (dNBR)

Line Fire 17,797.3 ha

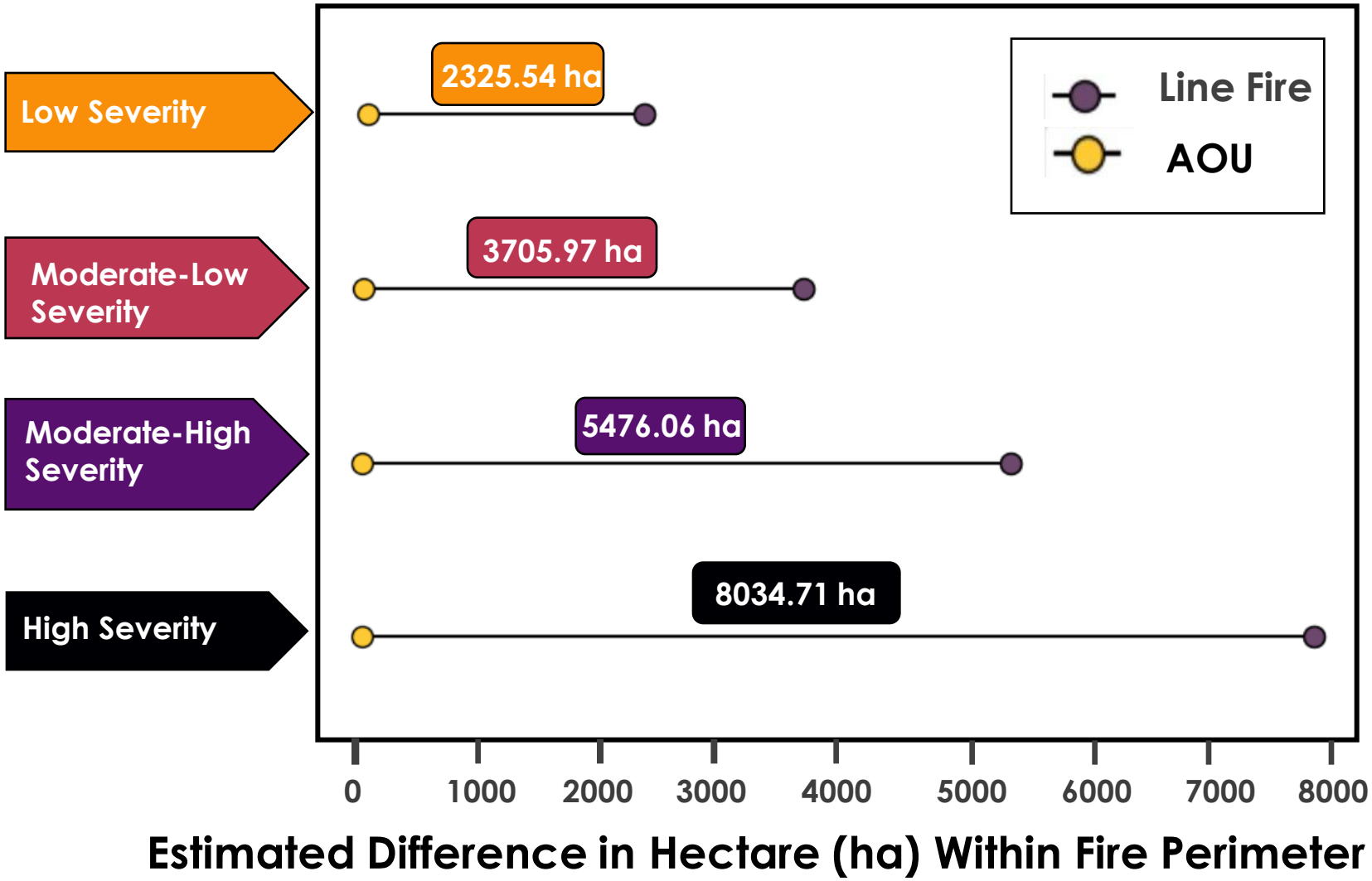


Prescribed Burn 80.9 ha



Color	DNBR Range	Severity Level
	-0.50 – 0.10	Unburned
	0.10 – 0.27	Low Severity
	0.27 – 0.44	Moderate - Low Severity
	0.44 – 0.66	Moderate - High Severity
	0.66 – 1.30	High Severity

Results: Comparing Fire Type Burn Severity by Hectare (ha)



Burn Severity Outcomes

In total, the **Line Fire** resulted in **17797.3 hectares** burned, in contrast to the **AOU's 80.9 hectares**.

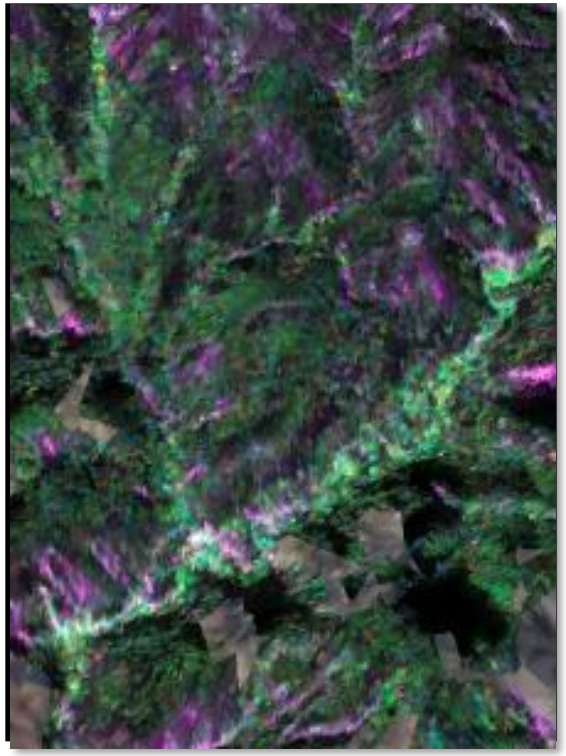
76% of the **AOU's burns** classified as **Low Severity**, while it only consisted for **12%** of the **Line Fire's burns**.

40% of the **Line Fire's burns** classified as **High Severity**, while **none** were identified in the **AOU**.

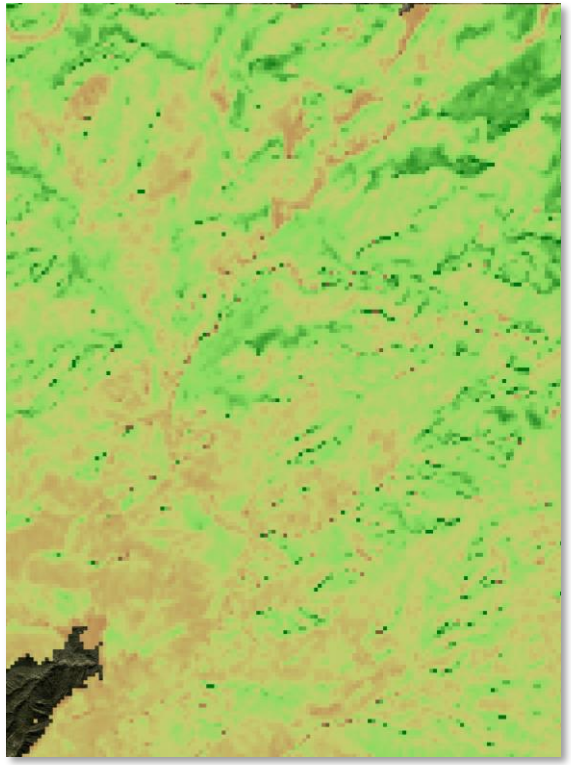
Errors, Uncertainty, & Feasibility

Validation | Spatiotemporal Resolution | Timeline

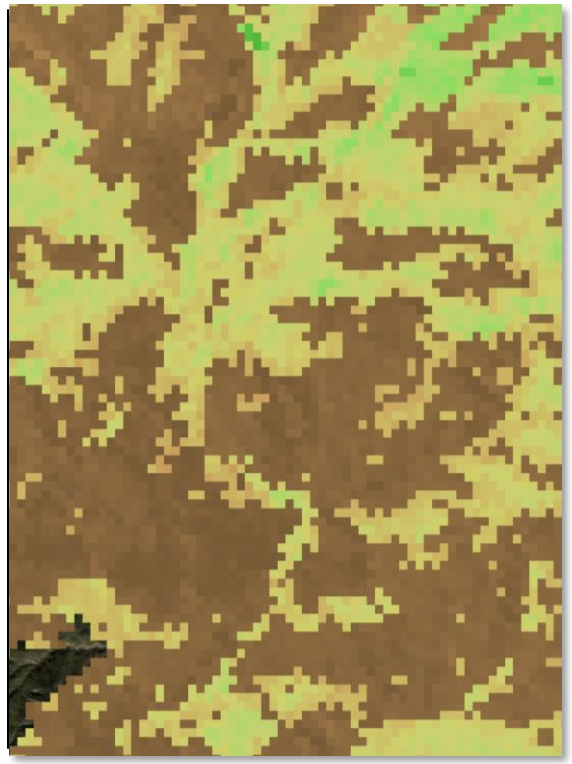
UAVSAR
6m, Intermittent



HLSL
30m, 8 days



EMIT
60m, Intermittent



ECOSTRESS
70m, Intermittent

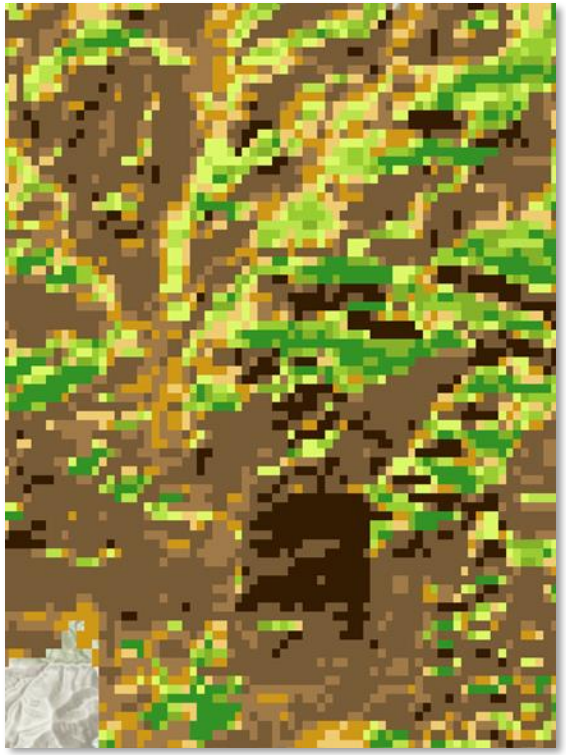



Image Credit: USDA Forest Service

Partner Implementation

- Deeper exploration into resilient post-fire vegetation
- Analysis on soil composition changes, post-fire sediment runoff in local water supplies and impacts on dams
- ISS EMIT could be leveraged for these analyses

Conclusions

Using a wide variety of Earth observation data allows us to more fully understand the impacts of prescribed burns.

- Natural case study proves **regular prescribed burns in the AOU areas reduced fire-fuel loads.**
- This **decreases the risk of wildfires** in this region **from spreading into nearby urban areas.**
- In these areas, Rx burns kept neighborhoods safe and **reduced the risk of wildfire devastation.**

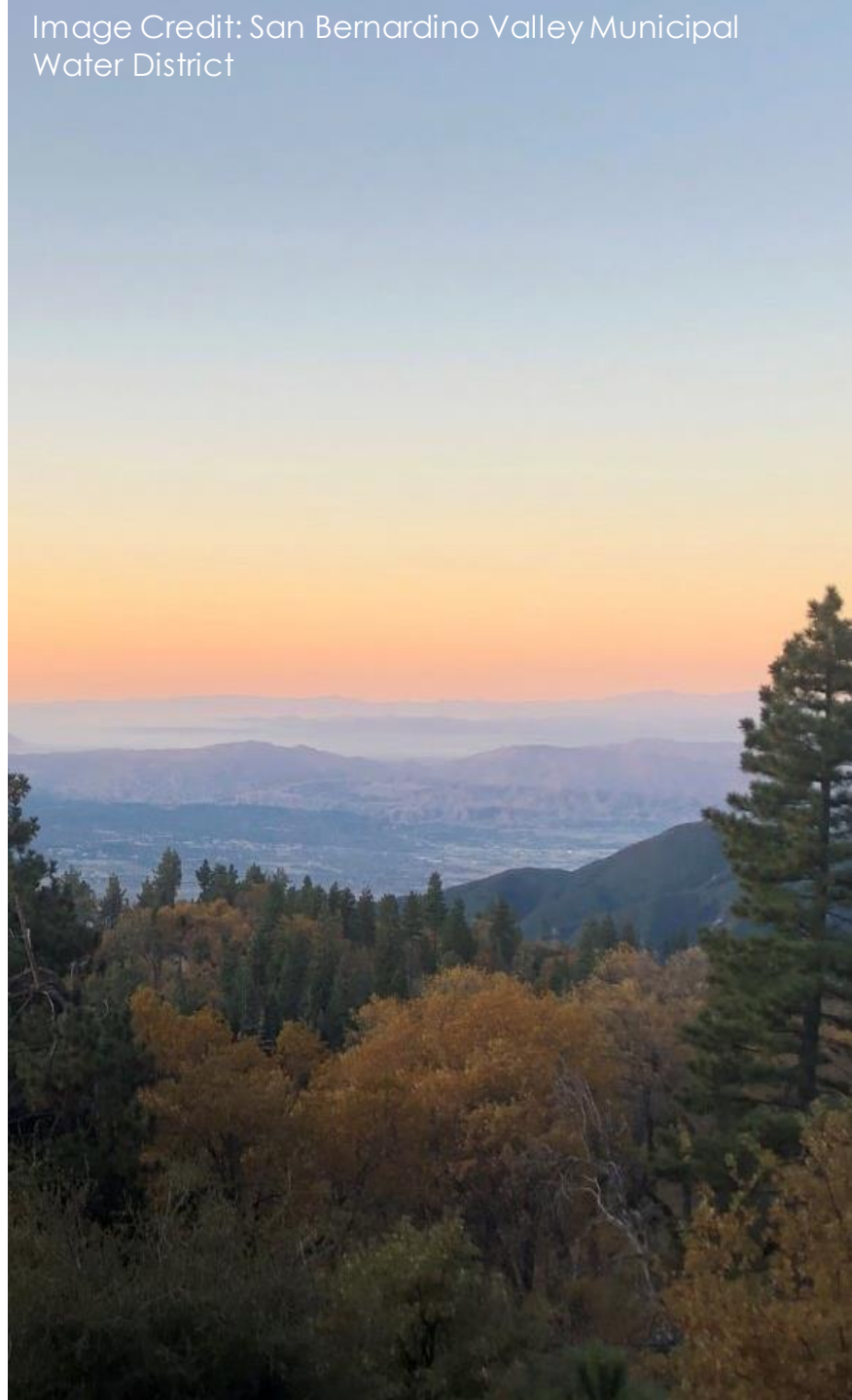


Image Credit: San Bernardino Valley Municipal Water District

Acknowledgements

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- Lauren Blake (USDA, San Bernardino national forest)
- Chris Jones (San Bernardino Municipal Water District)
- Dr. Jennifer Alford (CSUSB, Institute for Watershed Resiliency)
- Danielle Bram (CSUN, Center for Geospatial Science & Technology)

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Thank you!

Image Credit: San Bernardino Valley Municipal Water District

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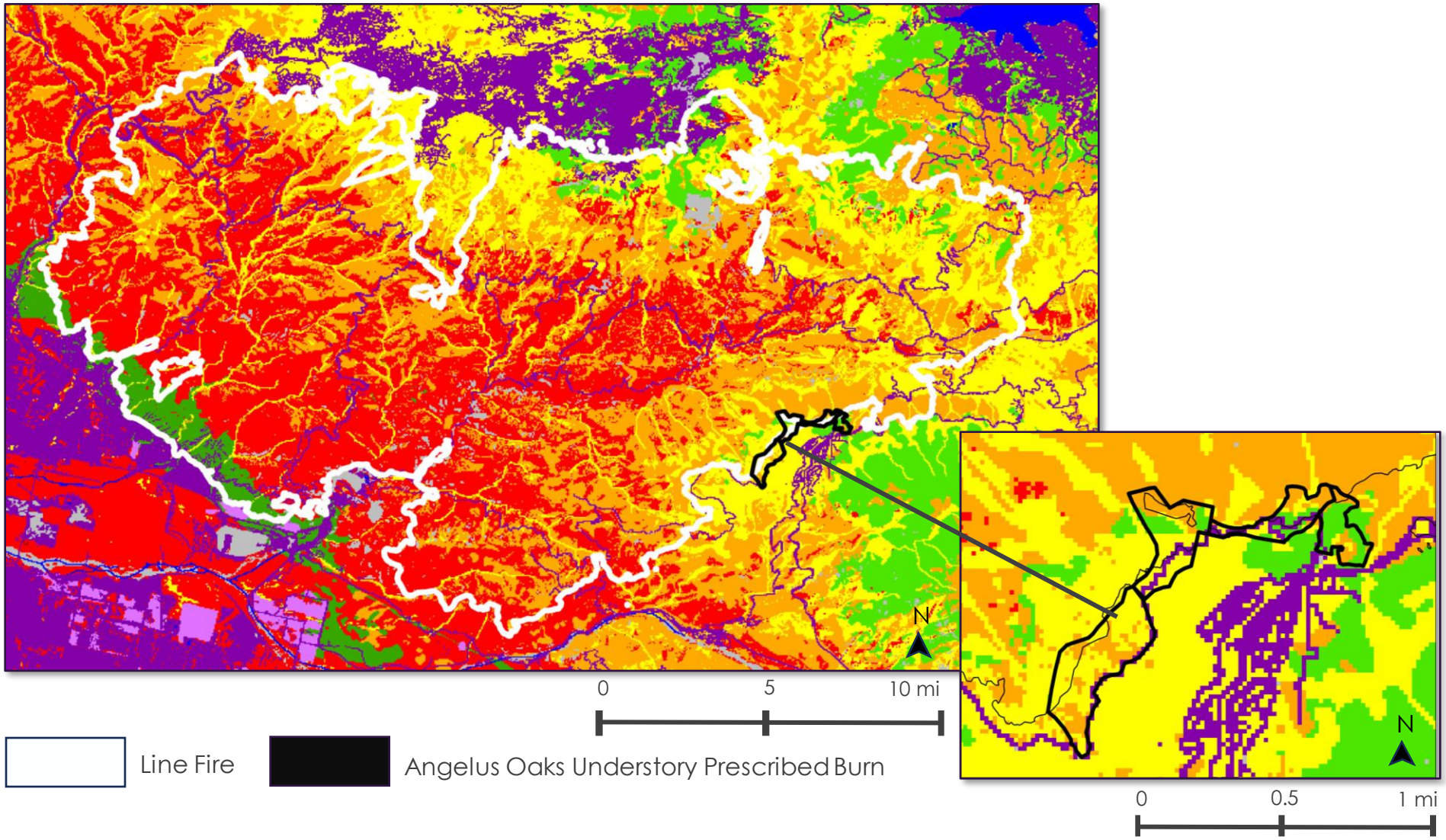
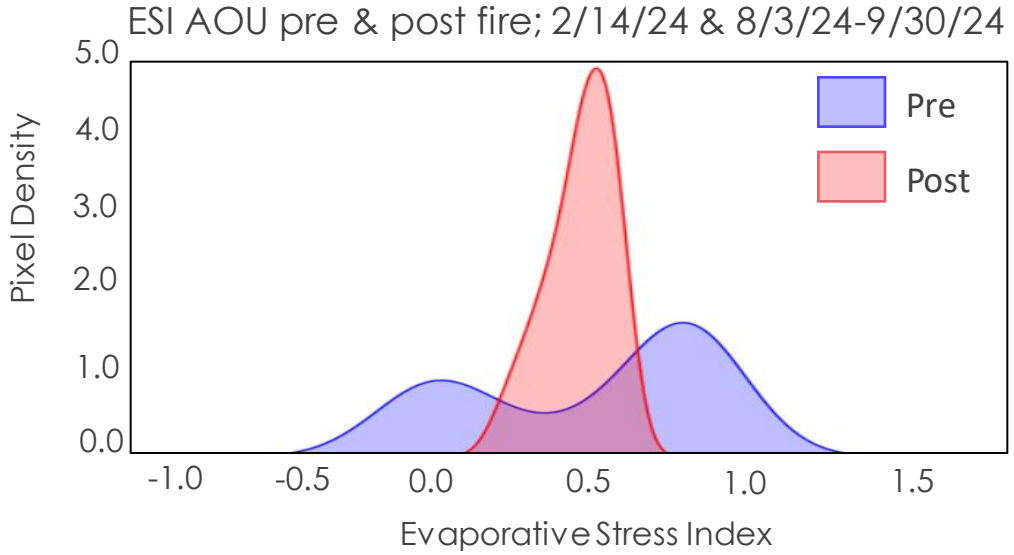
Land Cover Change with LANDFIRE

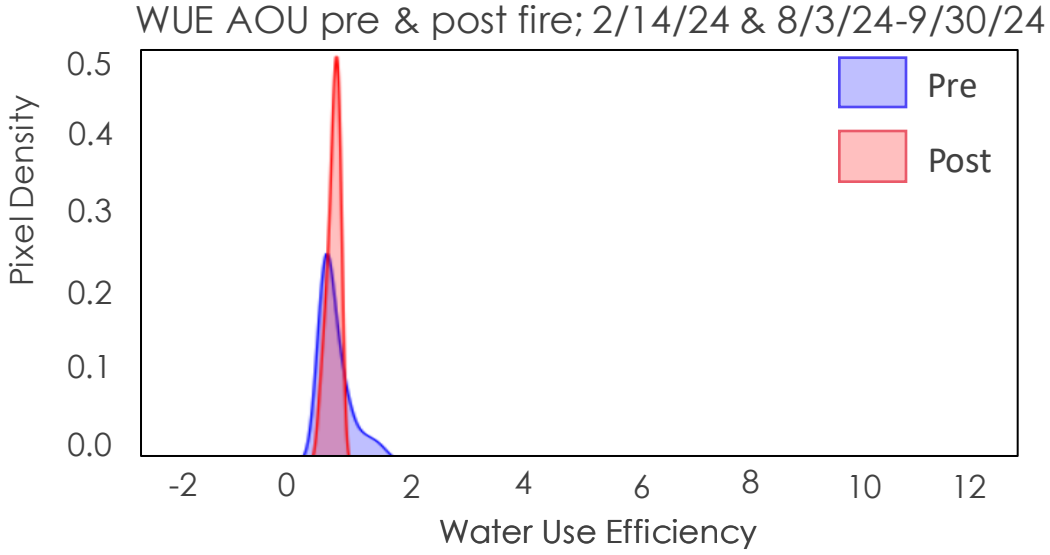
Vegetation Departure Ending in 2023

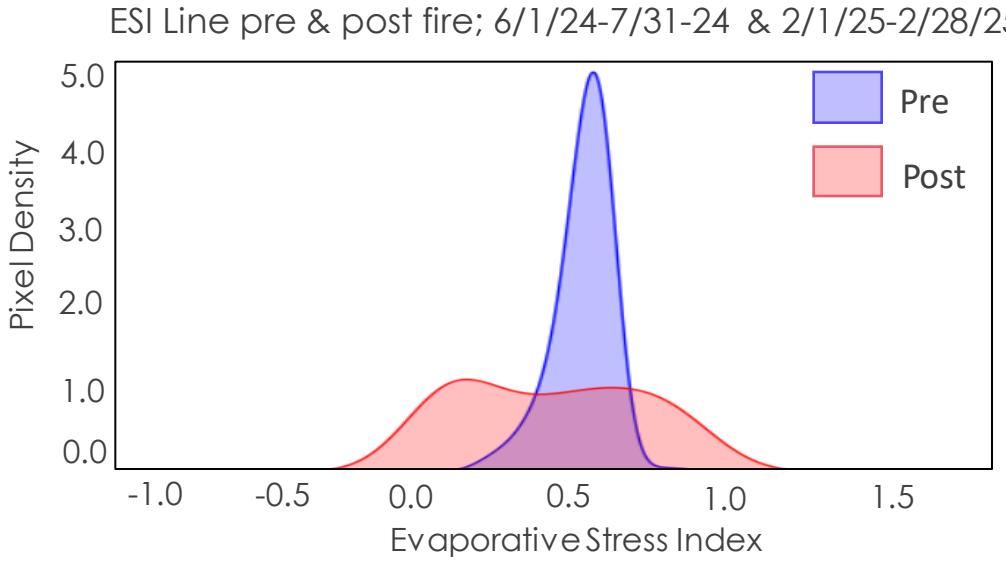
- Very Low, Vegetation Departure 0-16%
- Low to Moderate, Vegetation Departure 17-33%
- Moderate to Low, Vegetation Departure 34-50%
- Moderate to High, Vegetation Departure 51-66%
- High, Vegetation Departure 67-83%
- Very High, Vegetation Departure 84-100%
- Water
- Developed
- Barren or Sparce
- Agriculture

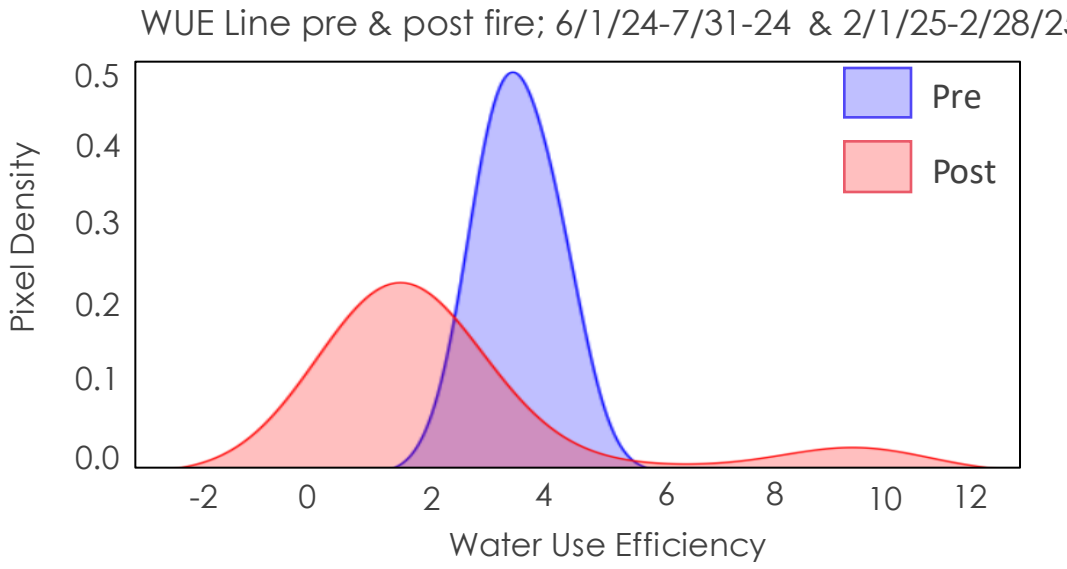


Results: ESI & Water Use Efficiency Change



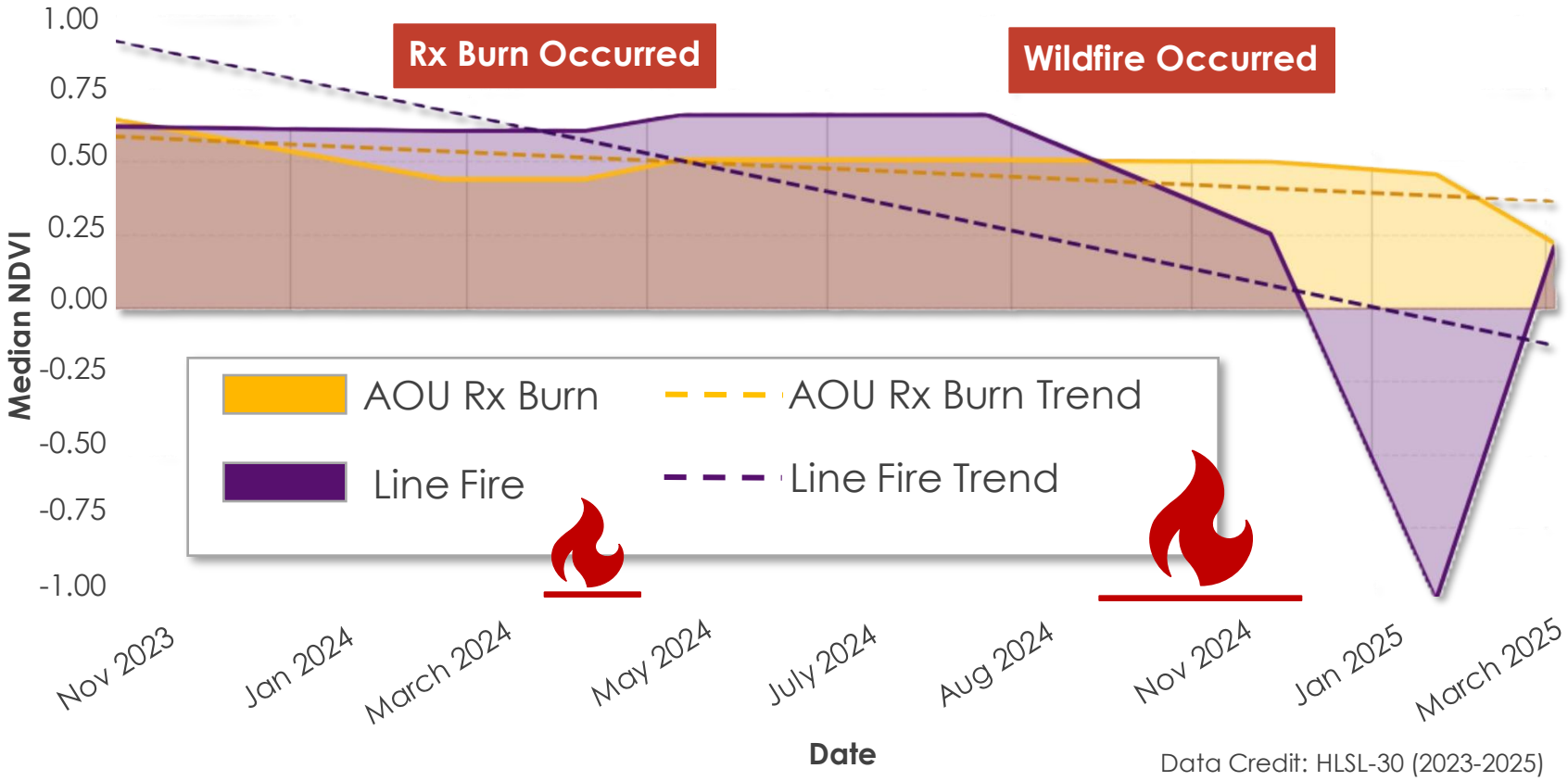






Results: NDVI
Landscape Greenness Trends Overtime

NDVI Time Series OLS Regression Analysis:
Angelus Oaks Understory Prescribed Burn vs Line Fire
(Nov 2023 – March 2025)



Data Credit: HLSL-30 (2023-2025)

Understanding Vegetation Recovery Rates

- Comparing AOU Rx Burn to the Line Fire, we see a **rapid decrease in greenness within the wildfire area** (purple).
- **Rx burn area** (gold) **greenness remained relatively constant over time.**

Note: this model does not include interactive variables and is subject to omitted variable bias. Significance threshold ($p < 0.05$)**

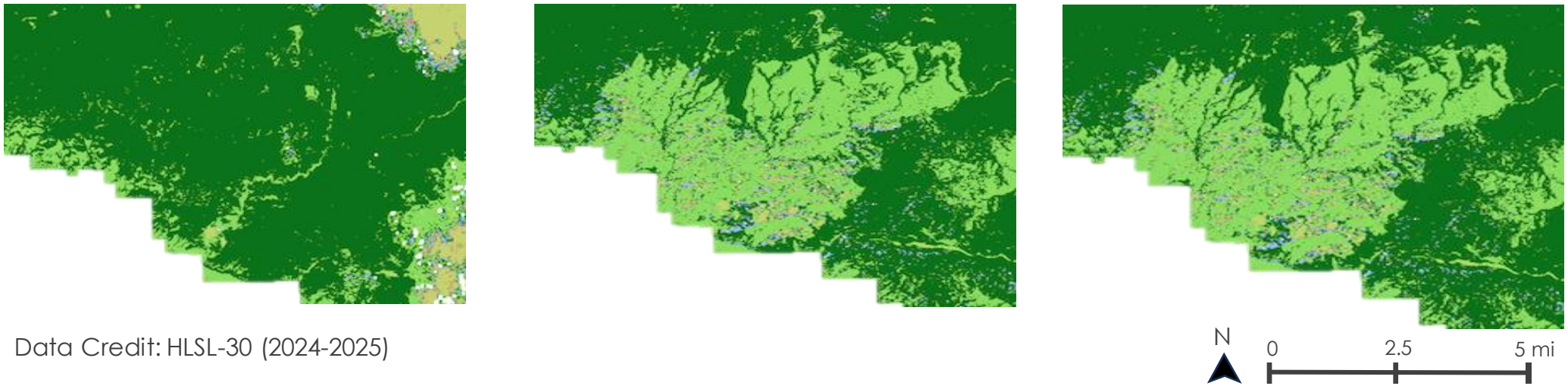
Results: EVI & Landscape Greenness Trends

Line Fire

(September 5 – December 21, 2024)

Enhanced Vegetative Index (EVI) provided greater insights on canopy coverage and vegetation greenness in these thicker areas. **The Line Fire primarily impacted areas with dense tree populations**.

Aug 1, 2024	Jan 23, 2025	Feb 22 & March 4, 2025
1 Month Before	1 Month After	3 Months After



Data Credit: HLSL-30 (2024-2025)

Results: Contrasting Fire Type Severity Trends