Phenological Classification and Atmospheric Drought Response of Riparian Vegetation in Drylands of the Southwestern United States

Conor A. F. McMahon, Dar A. Roberts, Michael B. Singer, Kelly K. Caylor, John C. Stella

AGU FALL MEETING

Research Goals

1) Delineate riparian vegetation on landscape scale

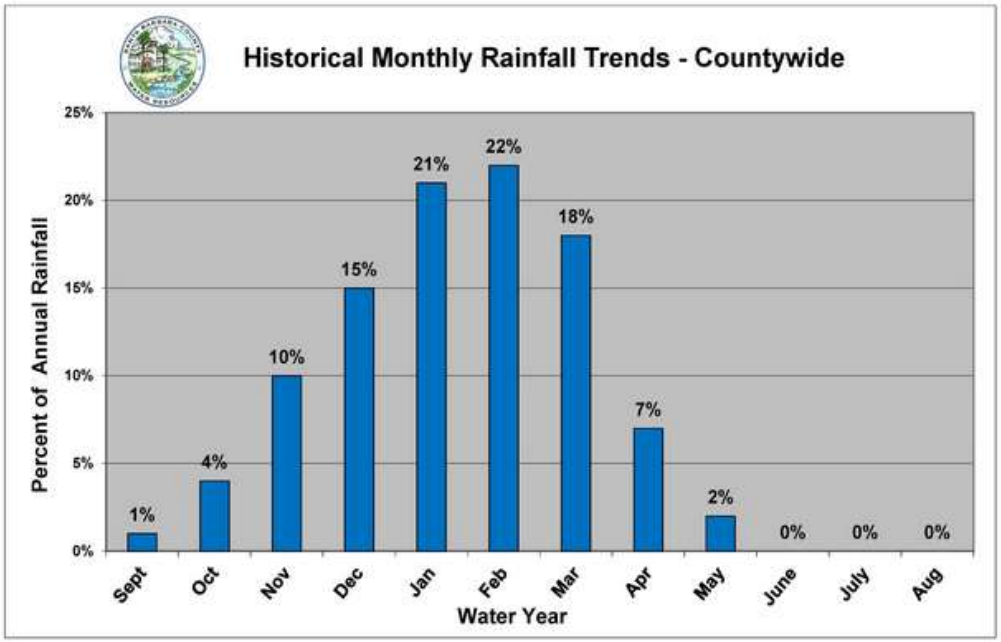
2) Assess interannual response to water availability

Riparian Zones in US Southwest

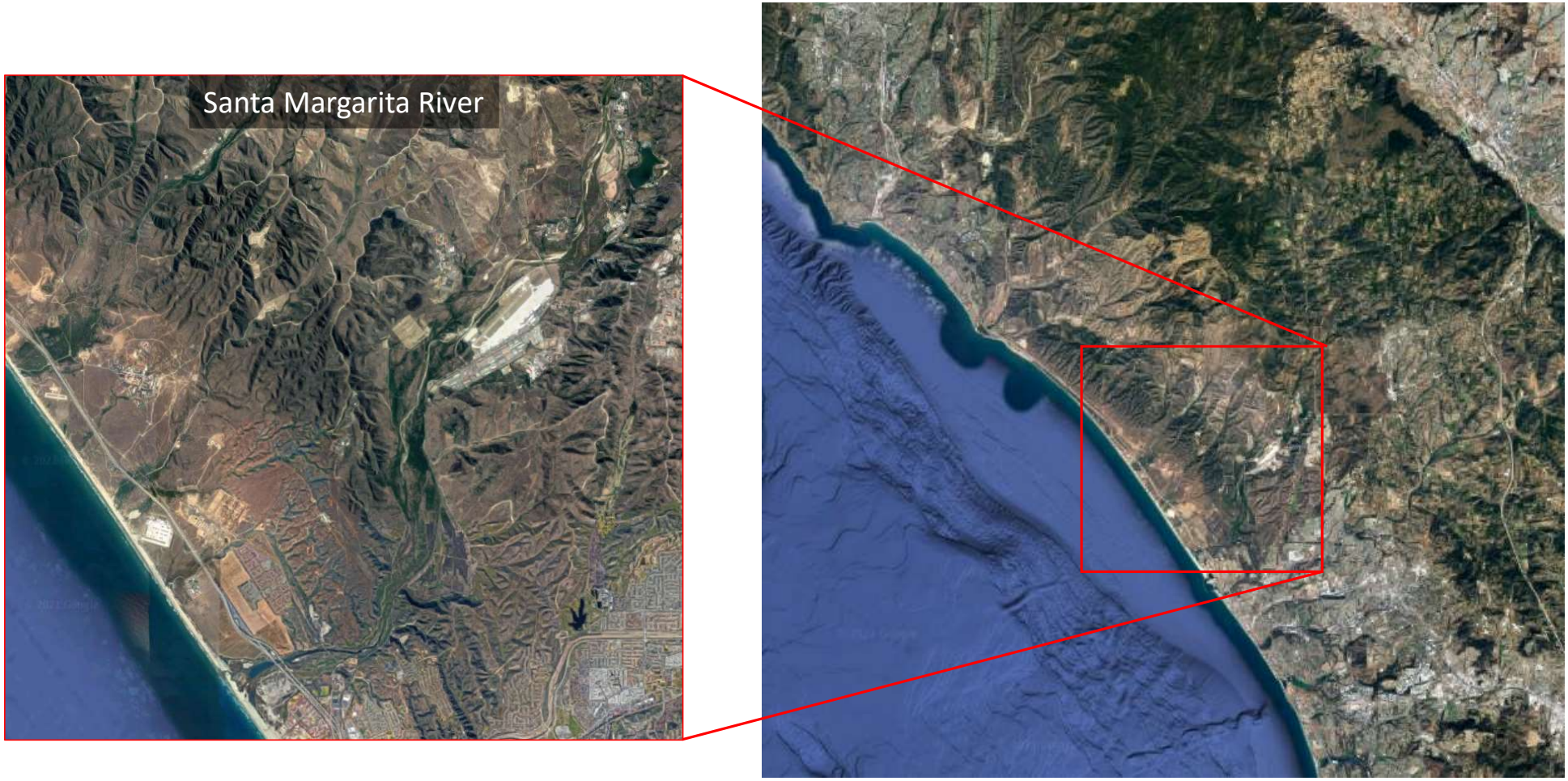
- Perennial water access
- Small fraction of land area (< 10%)
- Extremely Important
  - Diverse refugia for plants/animals
  - Large fraction of landscape productivity
  - Channel water during flood events
- Often Threatened
  - Conflict for water with agriculture
  - Conflict for land with development

Marine Corps Base Camp Pendleton

- Vegetation Types
  - Willow Riparian Woodland
  - Coastal Sage Scrub
  - Oak Woodland
  - Annual Grassland
- Mediterranean Climate
  - Wet, cool winters
  - Dry, mild summers



Marine Corps Base Camp Pendleton



What is Riparian?

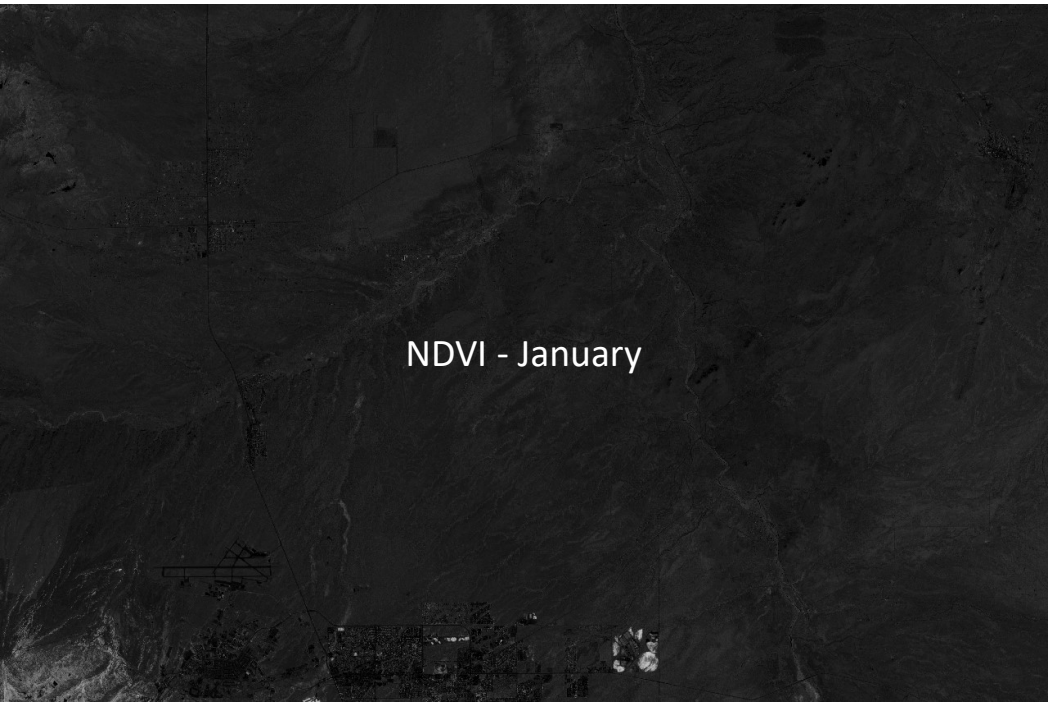


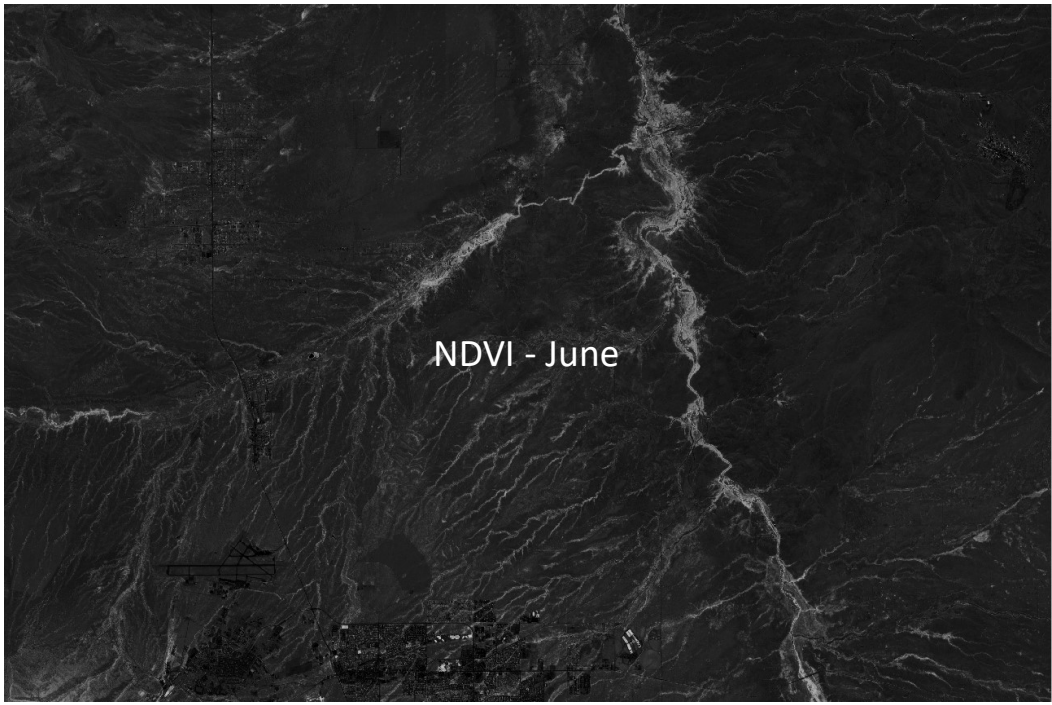



Riparian Plant Phenology

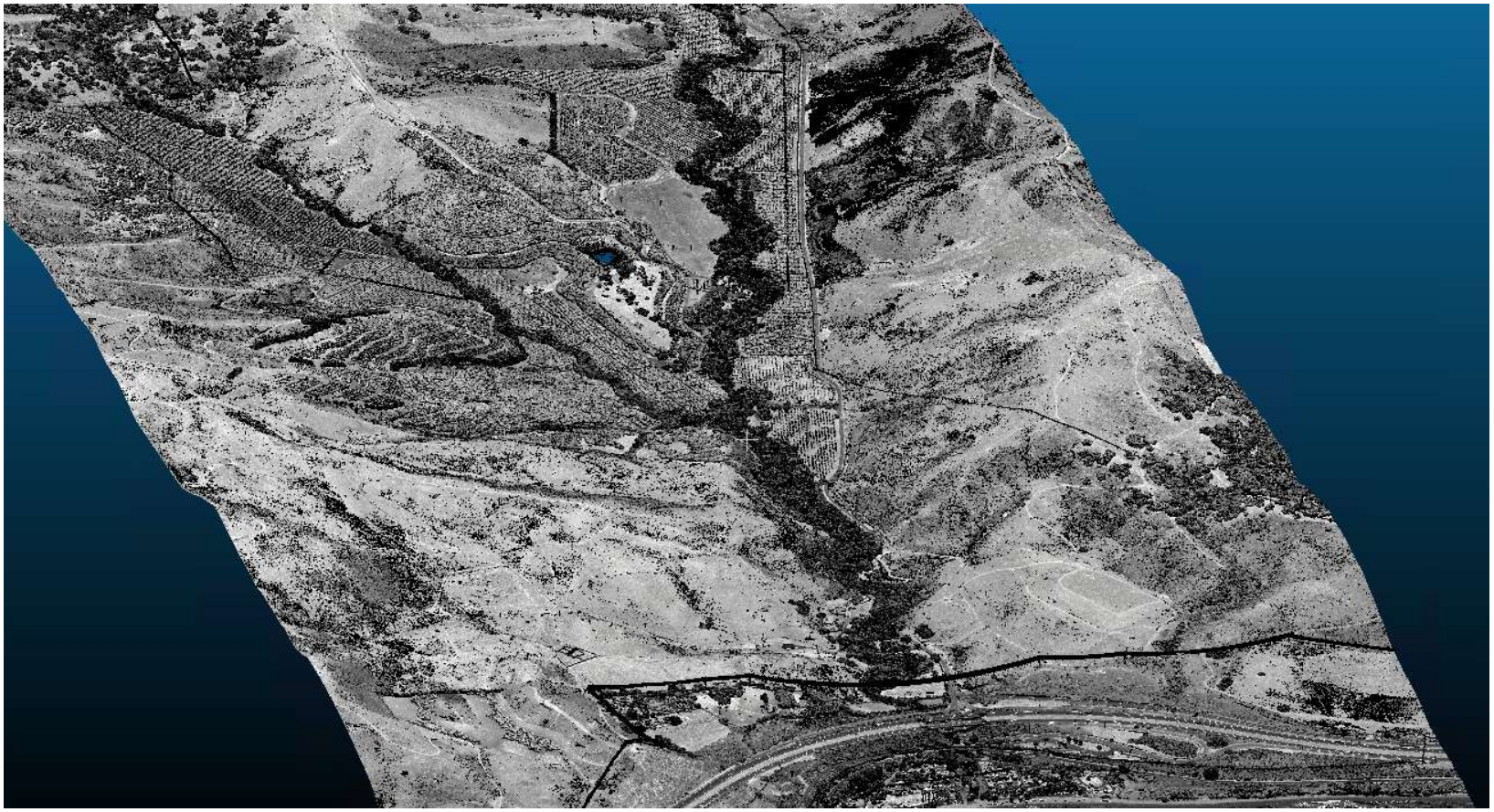
- Phenology – seasonal cycles of natural phenomena
- Deciduous plants undergo annual leaf cycles
  - **Leaf flush** in spring
  - **Leaf senescence** and drop in fall

Plant Phenology – Satellite Detection





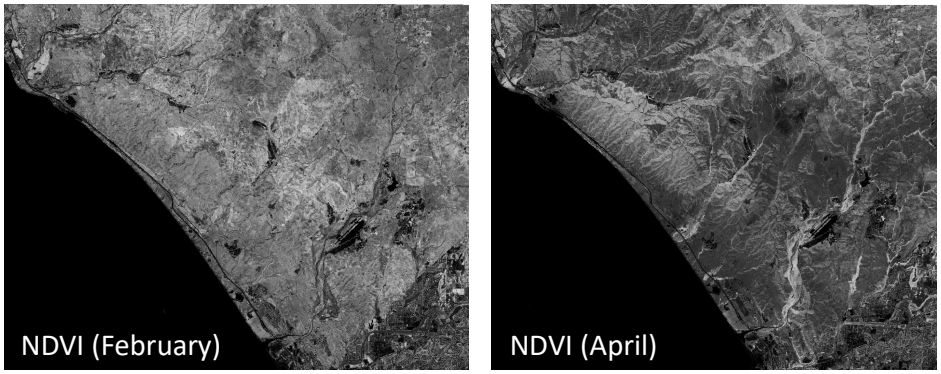
Vegetation Structure - LiDAR



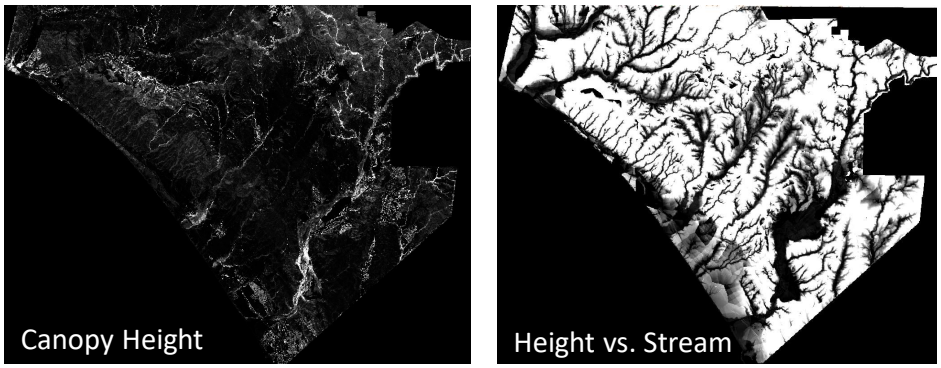
Phenological Classification of Vegetation Types

Input Data – 10 m

Sentinel-2-derived Phenology



LiDAR-derived Metrics

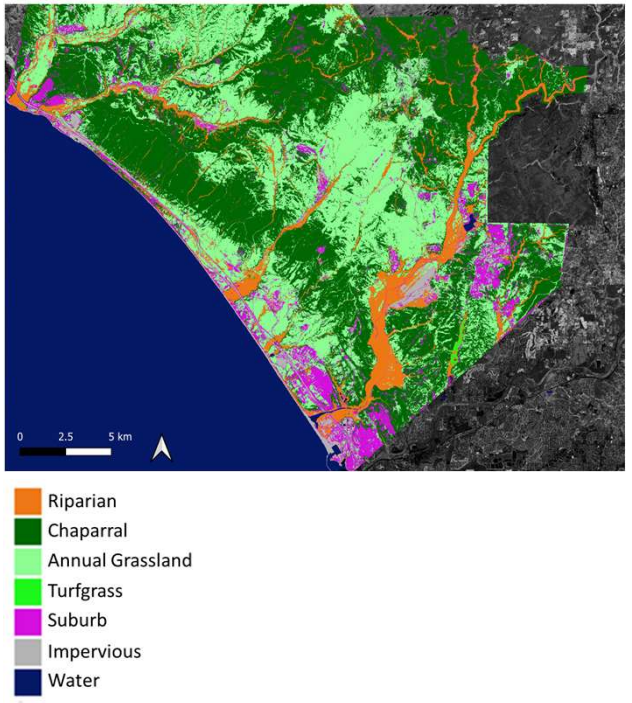


Training/Validation Polygons

Random Forest Classifier

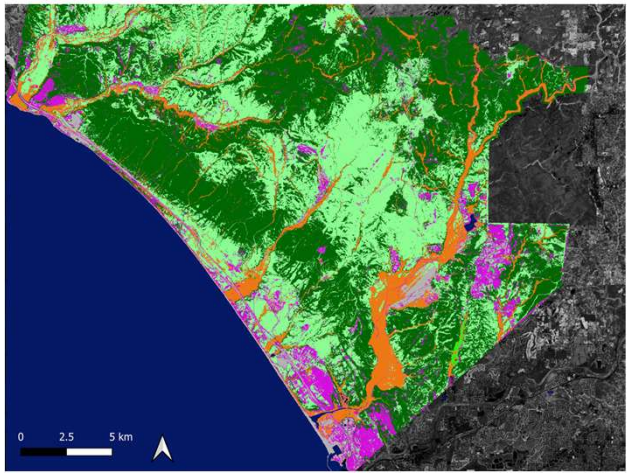
Output Classification

Camp Pendleton



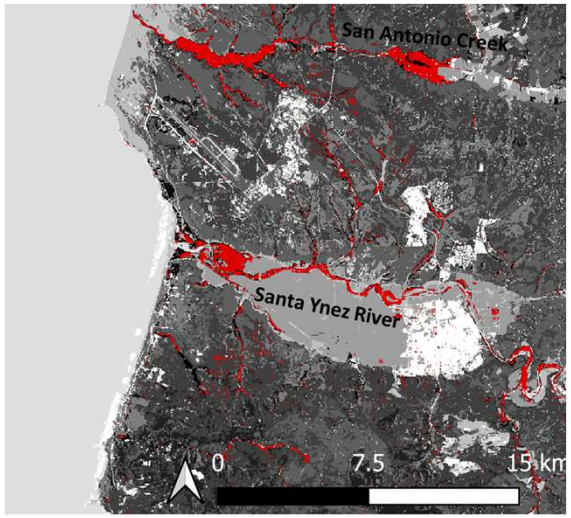
Phenological Classification of Vegetation Types

Camp Pendleton



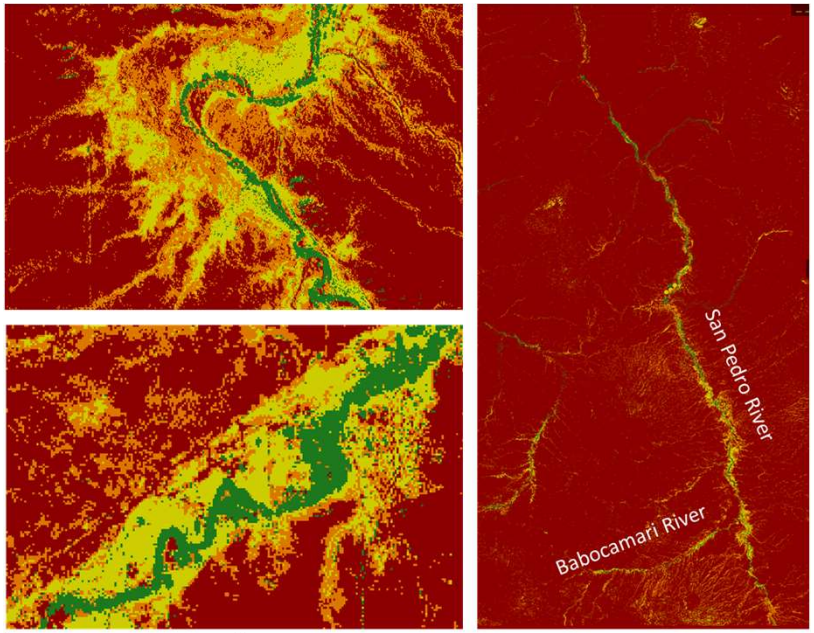
- Riparian
- Chaparral
- Annual Grassland
- Turfgrass
- Suburb
- Impervious
- Water

Vandenberg Air Force Base



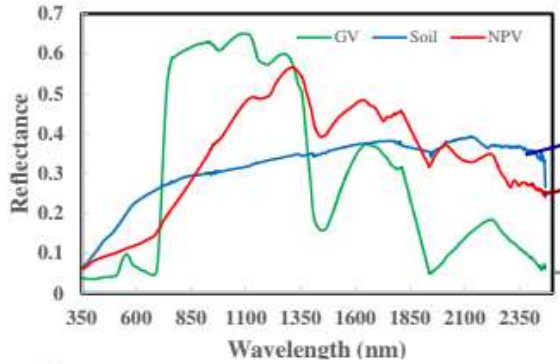
Riparian Communities in Red

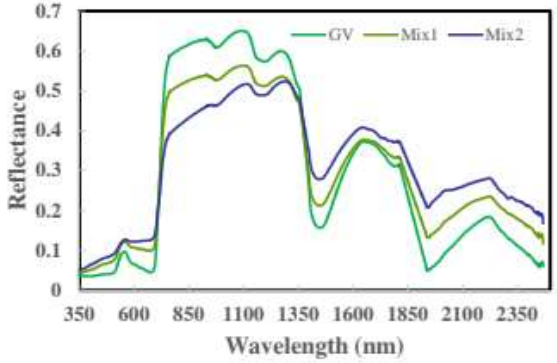
San Pedro and Babocomari Rivers

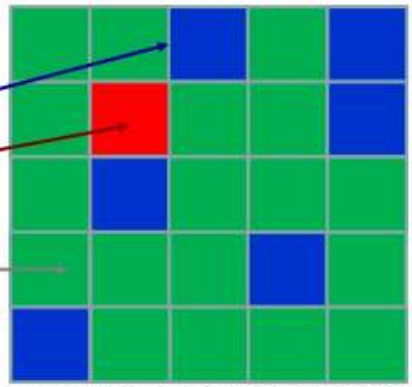


- Cottonwood
- Mesquite
- Herbaceous Plants
- Soil

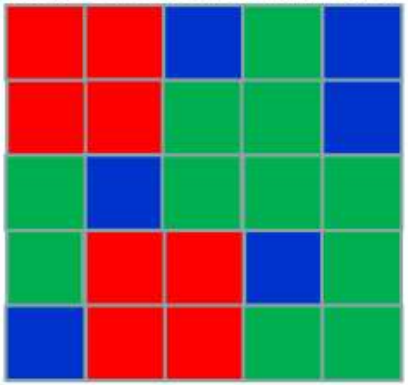
Multiple Endmember Spectral Mixture Analysis







Mix 1: 72% GV, 24% Soil, 4% NPV

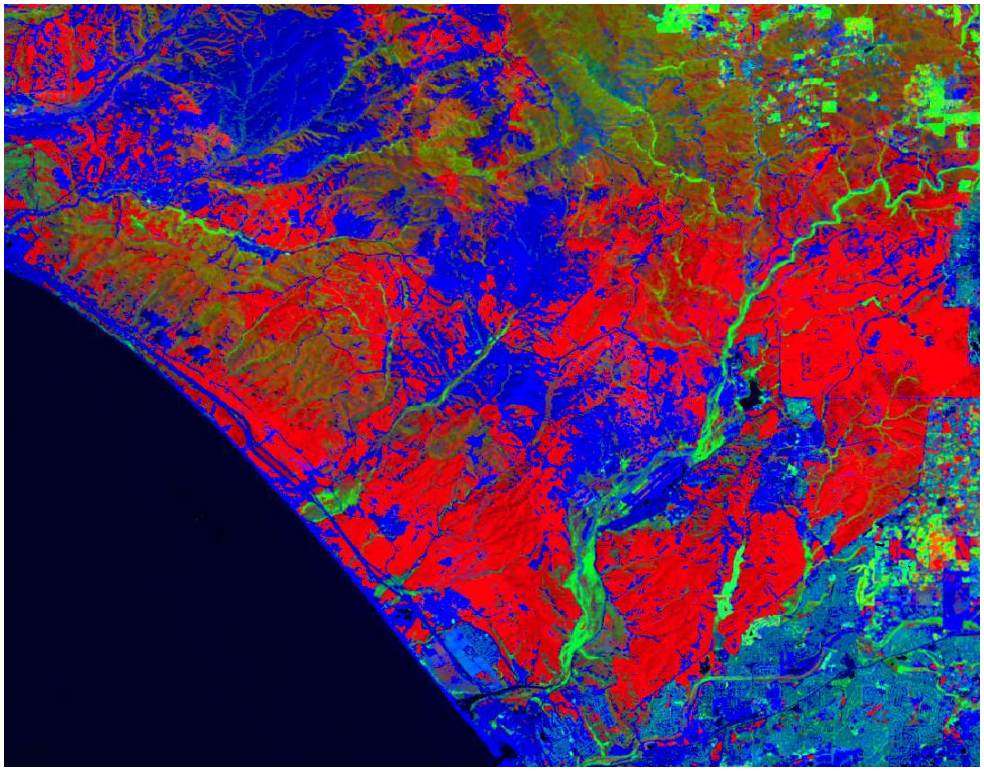


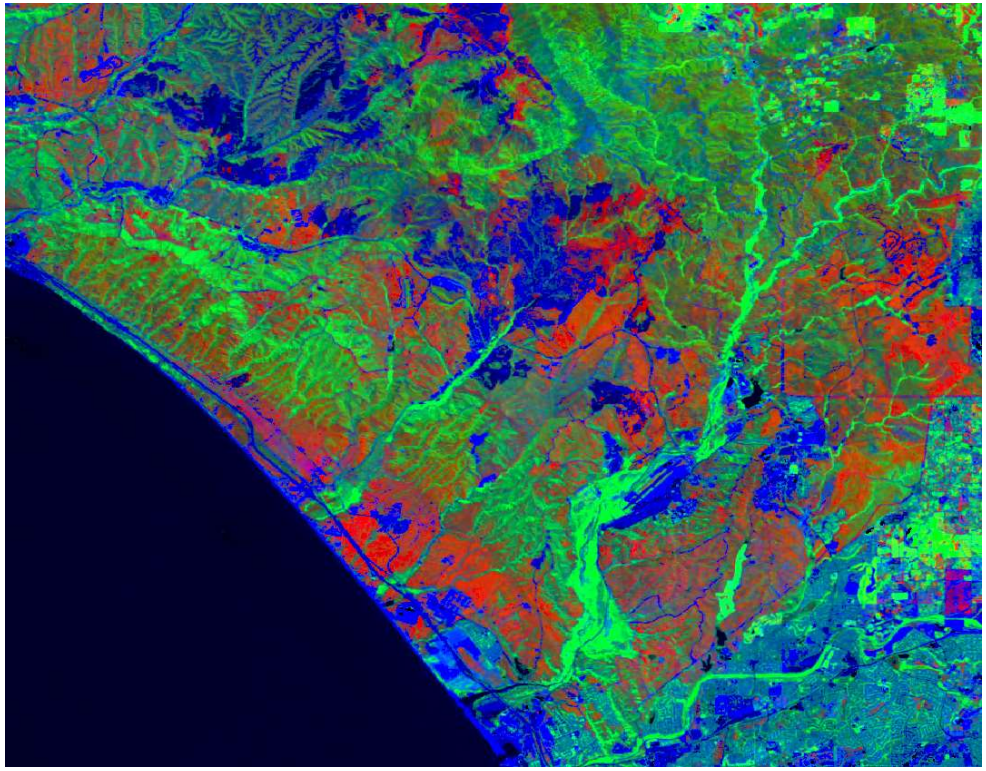
Mix 2: 44% GV, 24% Soil, 32% NPV

- **Sum of spectra in "pixel" weighted by the fraction of each component**

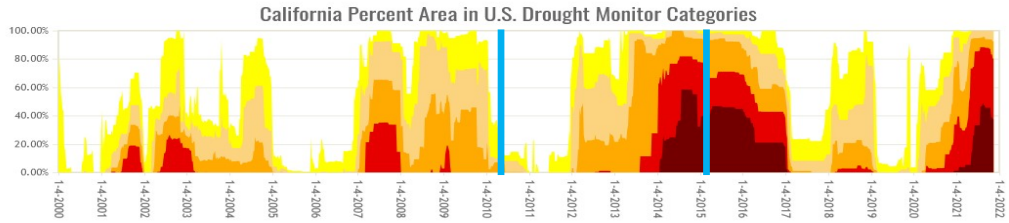
Roberts 2020

Multiple Endmember Spectral Mixture Analysis





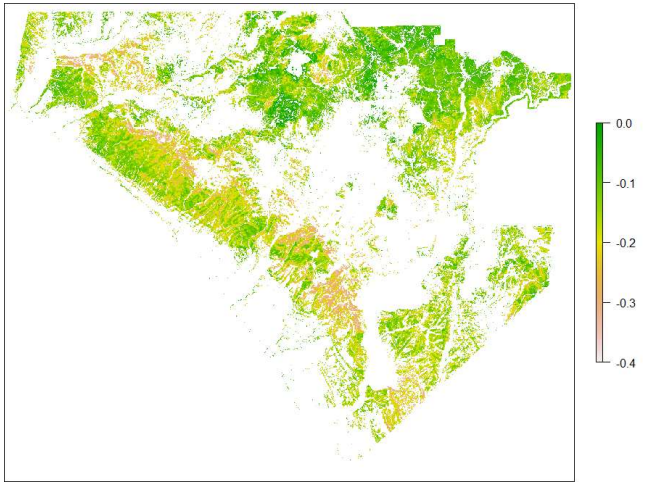
Green – Green Vegetation Fraction
Red – Non-photosynthetic Vegetation Fraction
Blue – Soil Fraction



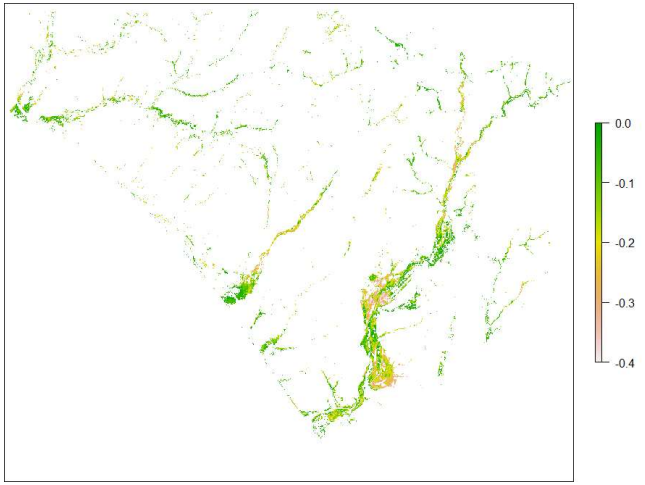
MESMA Case Study Across Camp Pendleton

Drought-induced Loss of Greenness (2015 vs. 2010 comparison)

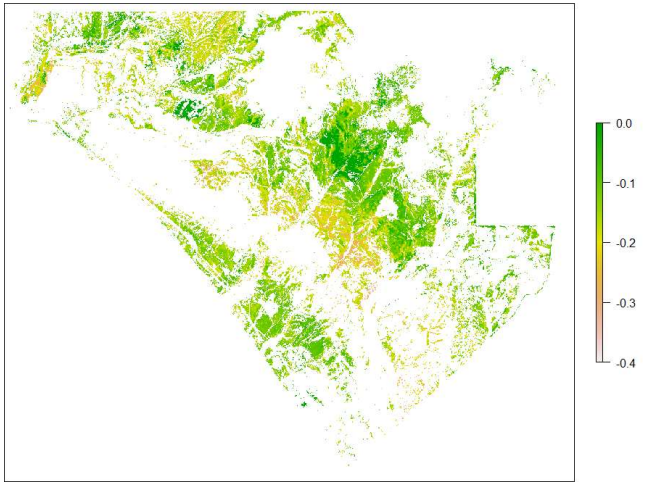
Chaparral



Riparian Woodland



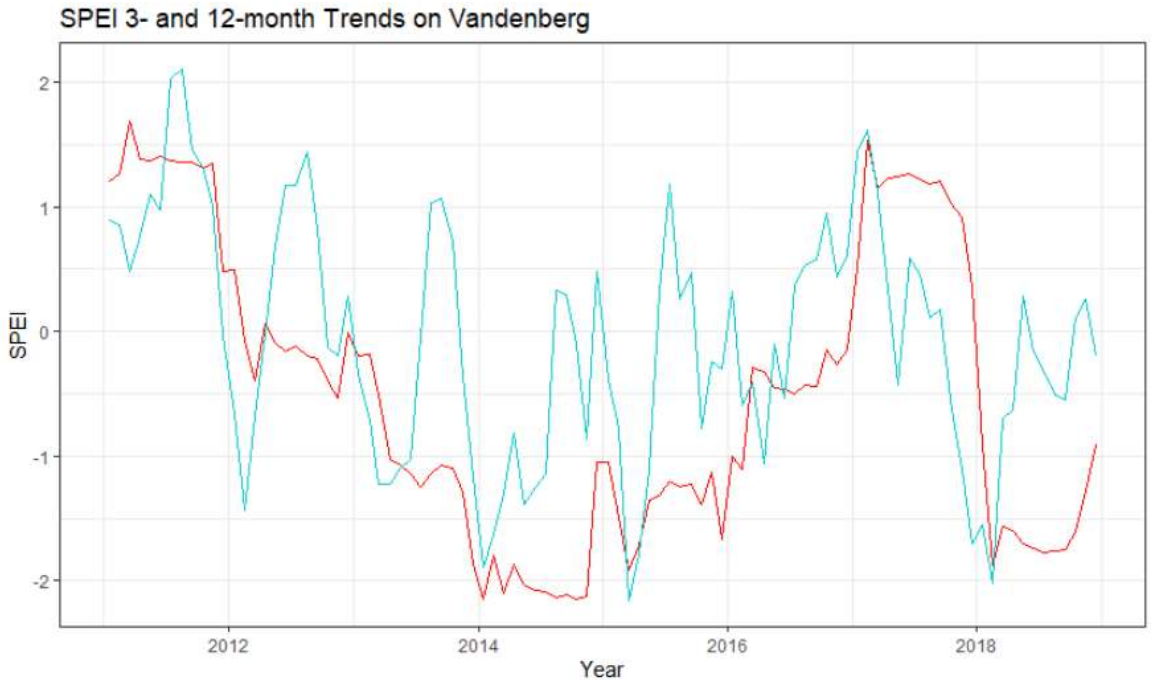
Annual Grassland



More-negative, orange-colored areas correspond to a larger decrease in greenness fraction from before the drought (2010) to during the drought (2015). Green areas showed no change or an increase in greenness under drought.

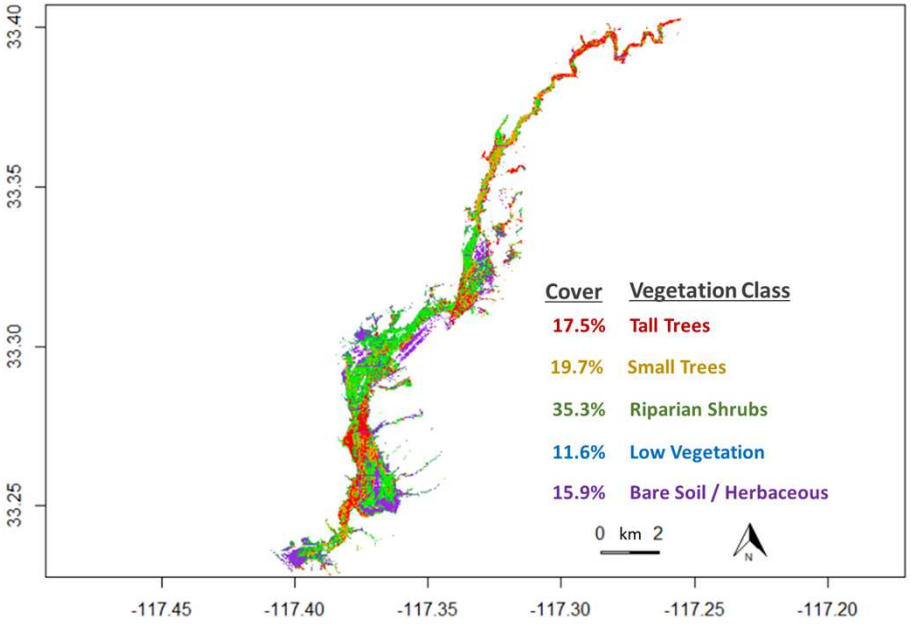
Drought Indicators – SPEI

- Standardized Precipitation-Evapotranspiration Index
- Approximates water availability to shallow-rooted plants
- Multiple temporal scales

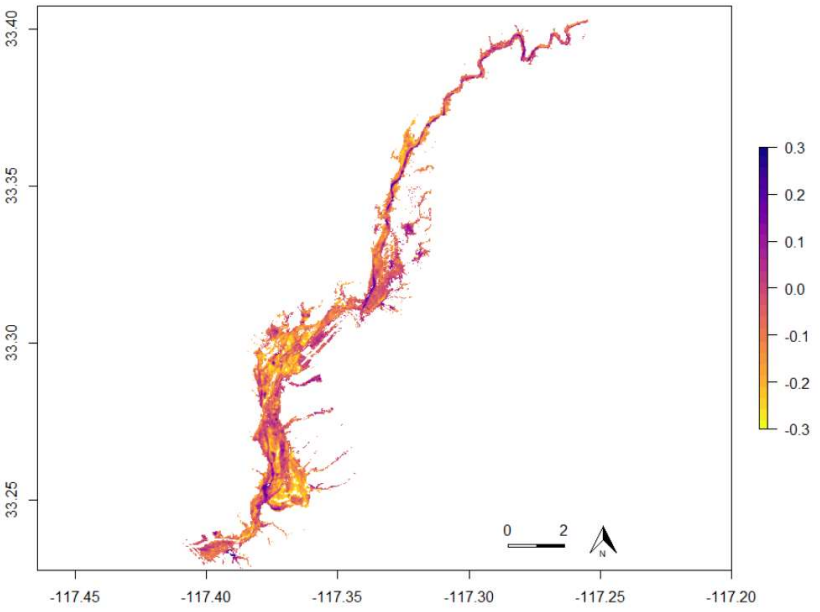


Plant Functional Types on the Santa Margarita

Vegetation Structural Class



Drought-induced Loss of Greenness

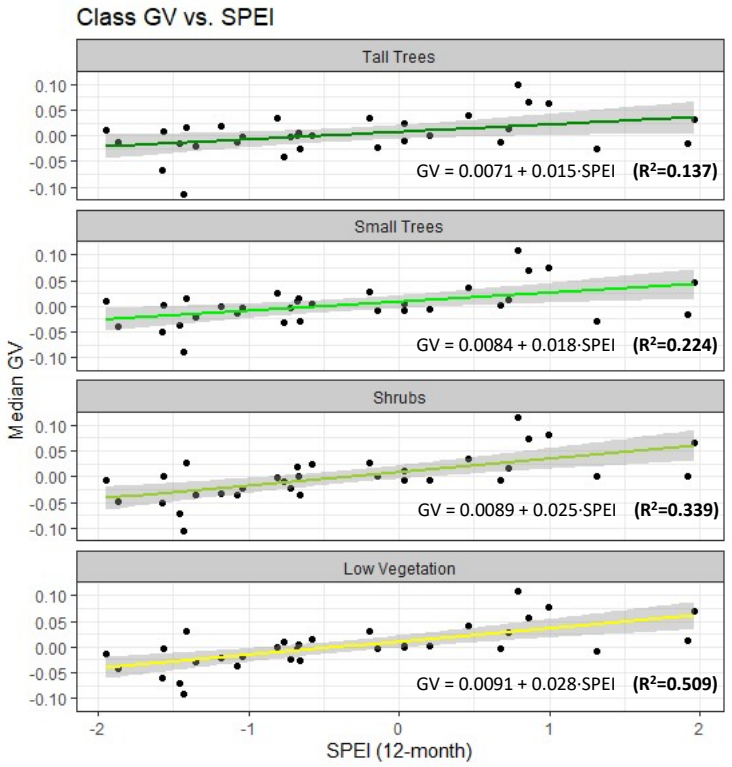


MESMA Case Study on the Santa Margarita River

Riparian GV-SPEI (12) Linear Models

	R	Adj. R^2	Slope	Intercept	P-value
Large Trees	0.4064	0.1373	0.0145	0.0071	0.0210 *
Small Trees	0.4987	0.2236	0.0175	0.0084	0.0037 **
Shrubs	0.6391	0.3887	0.0262	0.0089	8.24e-5 ***
Low Vegetation	0.7247	0.5093	0.0278	0.0091	2.74e-6 ***
Bare / Herbaceous	0.6727	0.4343	0.0259	0.0103	2.46e-5 ***

The relationship between soil moisture drought (SPEI) and greenness becomes progressively weaker for larger riparian plants, implying a subsidy provided by riparian groundwater. Larger, deeper-rooted trees are more readily able to access this subsidy than smaller shrubs and herbaceous riparian vegetation.

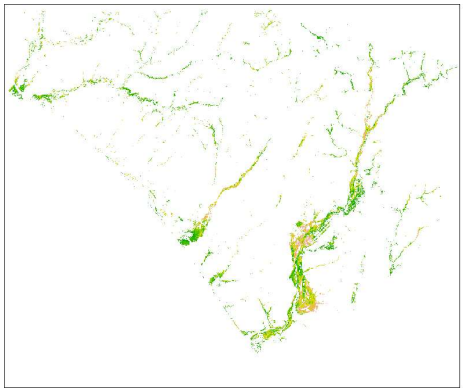


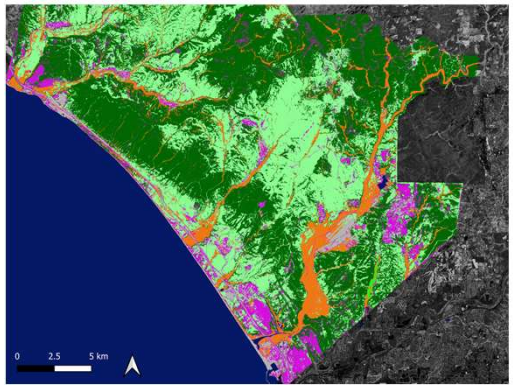
Major Takeaways

- Dryland PFTs can be delineated using phenology and structure
- Riparian plants respond negatively to drought
- This relationship is weakest for the largest (phreatophytic) trees

Riparian GV-SPEI (12) Linear Models

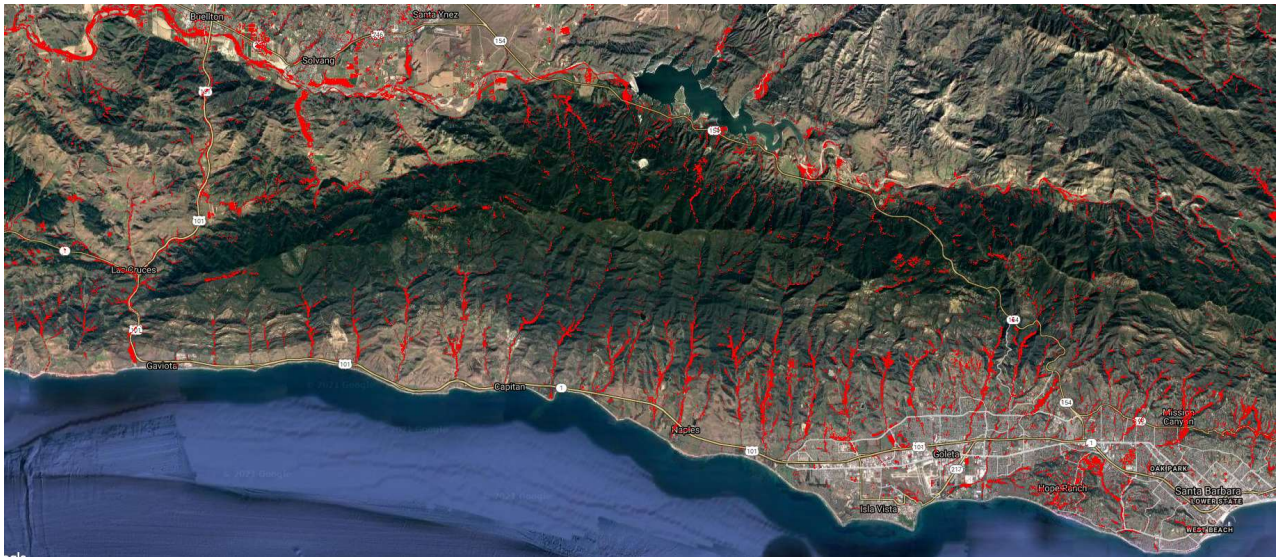
	R	Adj. R^2	Slope	Intercept	P-value
Large Trees	0.4064	0.1373	0.0145	0.0071	0.0210 *
Small Trees	0.4987	0.2236	0.0175	0.0084	0.0037 **
Shrubs	0.6391	0.3887	0.0262	0.0089	8.24e-5 ***
Low Vegetation	0.7247	0.5093	0.0278	0.0091	2.74e-6 ***
Bare / Herbaceous	0.6727	0.4343	0.0259	0.0103	2.46e-5 ***

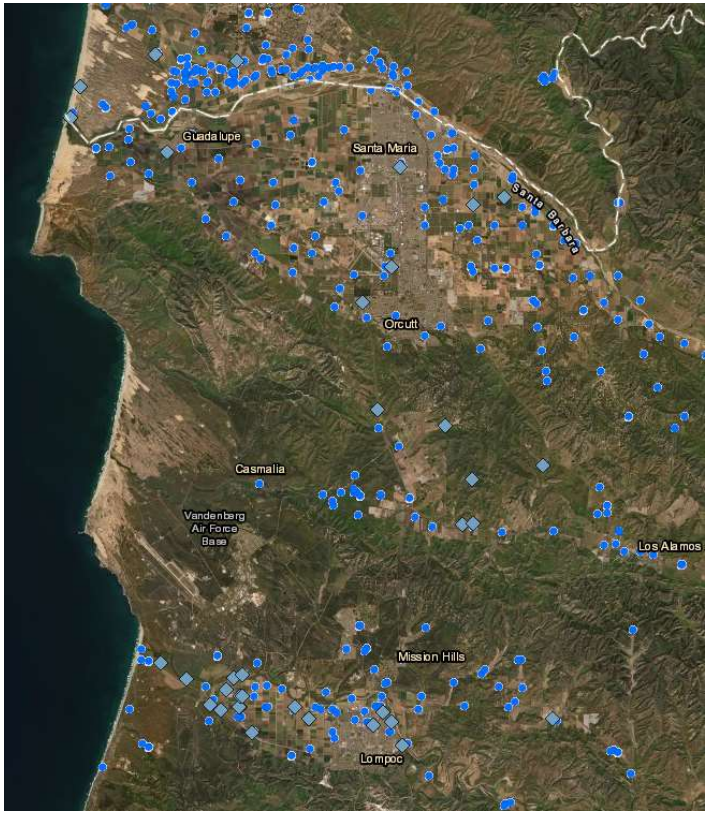




Next Steps

- Groundwater and spatial variability
- Regional analysis (Google Earth Engine)
- Modeling future outcomes



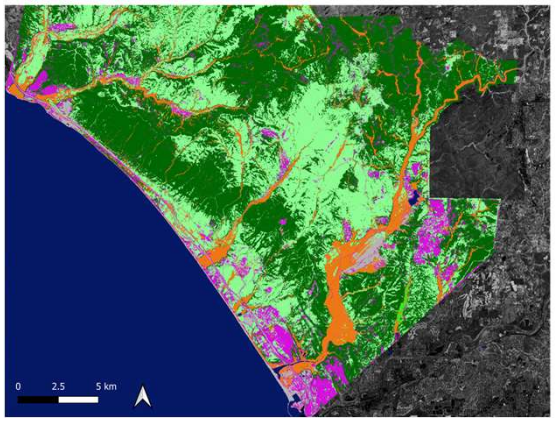


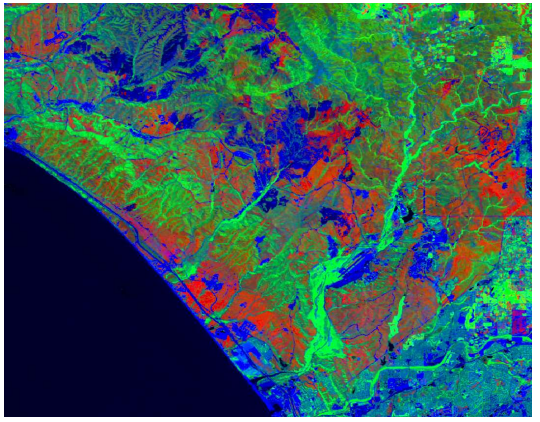
Thank you!

Viper Lab

Advisor: Dar Roberts

Committee: Anna Trugman, Kelly Caylor, Michael Singer, John Stella

UC SANTA BARBARA
Geography

SERDP
DOD • EPA • DOE

ESTCP