The Dynamics of a Semi-Arid Region in Response to Climate and Water-Use Policy

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PROJECT OBJECTIVES

5 Principal Areas of Investigation:

1) Response of bajada and valley floor shrub communities to a pronounced drought
2) Response of riparian and phreatophyte communities to a pronounced drought
3) Response of riparian and phreatophyte communities to additional stress imposed by groundwater drawdown
4) Response of all of these groups to increased precipitation and groundwater recharge, and reduced groundwater pumping (recovery)
5) Characteristics and magnitude of change of both the natural and managed systems of Owens Valley over 15 years in response to natural and socially-driven forces

PROJECT OBJECTIVES

What are the modes of response of arid and semi-arid systems to climatic variability and anthropogenic stress?

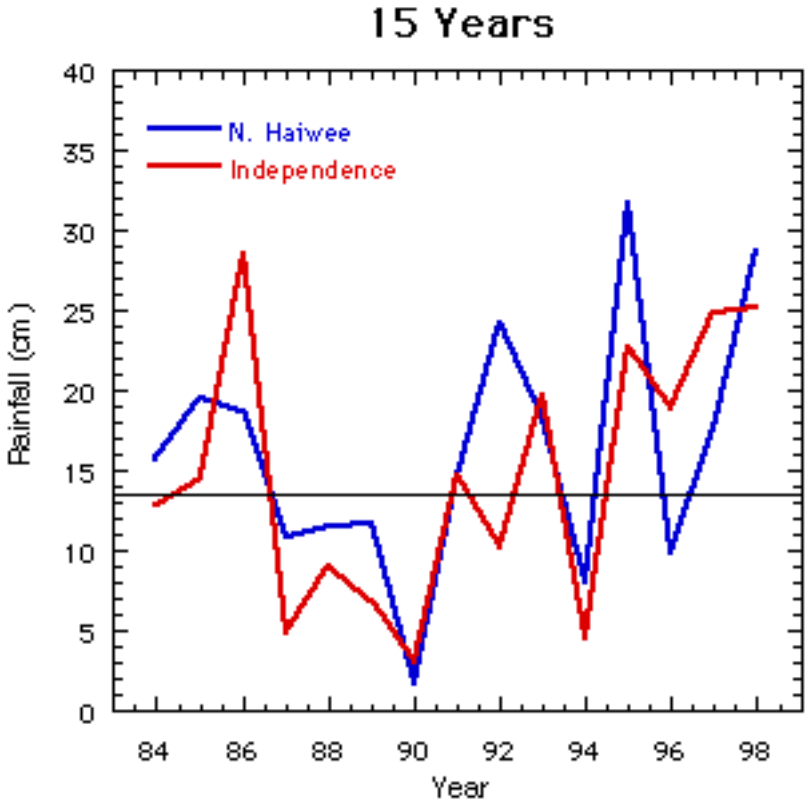
Case Study in Owens Valley CA

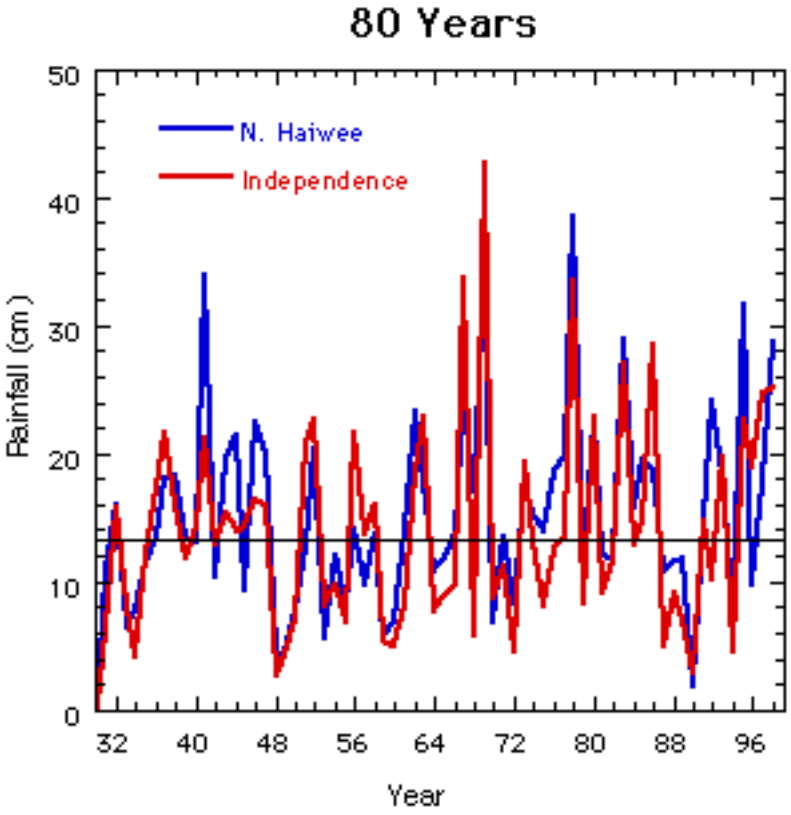
- Climate variability over the last 20 years
- Mosaic of ecosystems (riparian => shrubland)
- Competition for water resources:
  - Ecosystems ⇔ Local ⇔ Regional
- Large changes observed
- Excellent ground control at specific sites
- Management of resources tied to ecological health
- Remotely sensed data required to scale local observations to regional perspectives

Methodology and Approach

- Reduction of Remote Sensing Data to obtain estimates of green vegetation abundance, validation of technique
- Classify change vectors into functional response groups
- Establish relationships between functional groups and physical/climatological/land-use data base
- Determine response of systems to both climatic variability and anthropogenic stress

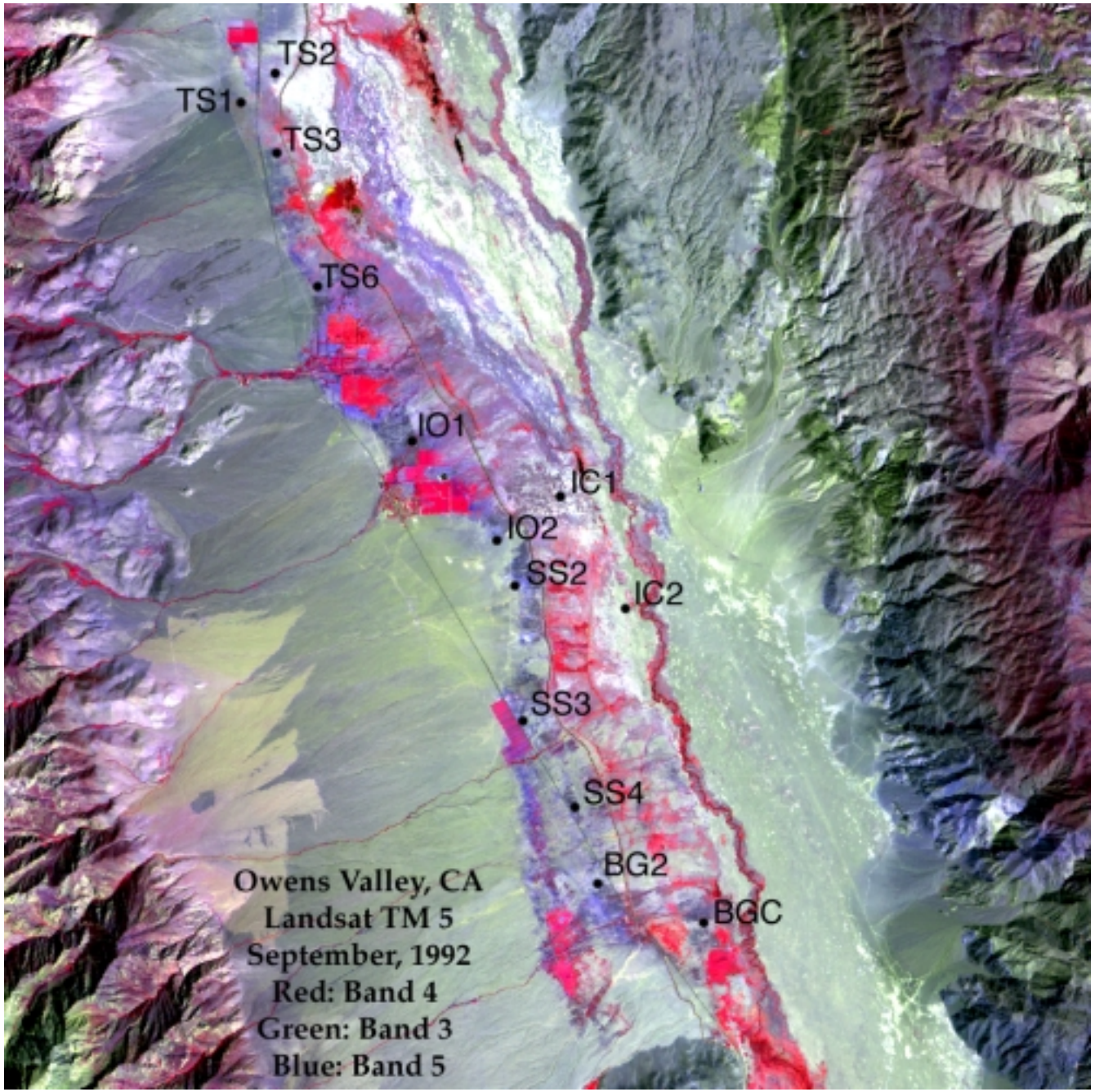
Precipitation





Processing Steps

- Co-registration
- Geo-referencing
- Spectral Calibration
- Spectral Mixing Model
- Field Measurements
- Field Site Location Finding
- Statistical Analysis

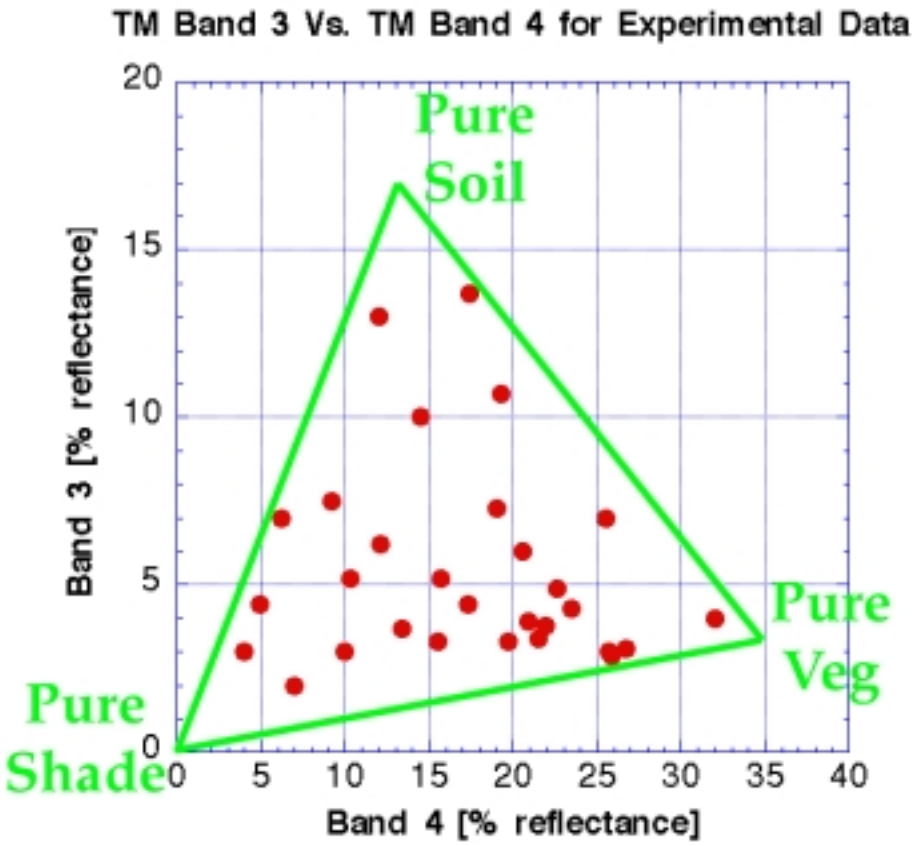

TS2
TS1
TS3
TS6
IO1
IC1
IO2
SS2
IC2
SS3
SS4
BG2
BGC
Owens Valley, CA
Landsat TM 5
September, 1992
Red: Band 4
Green: Band 3
Blue: Band 5

Spectral Mixture Analysis

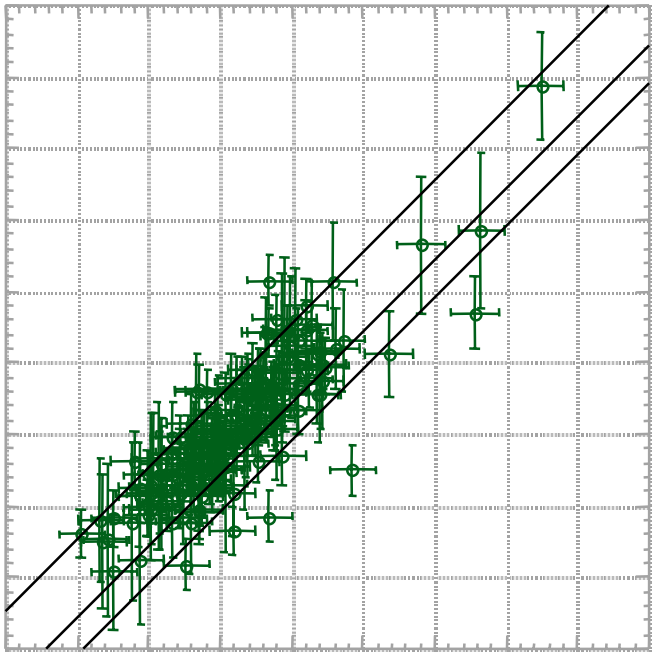
$$DN_b = \sum_{i=1}^{N} F_i DN_{i,b} + E_b$$

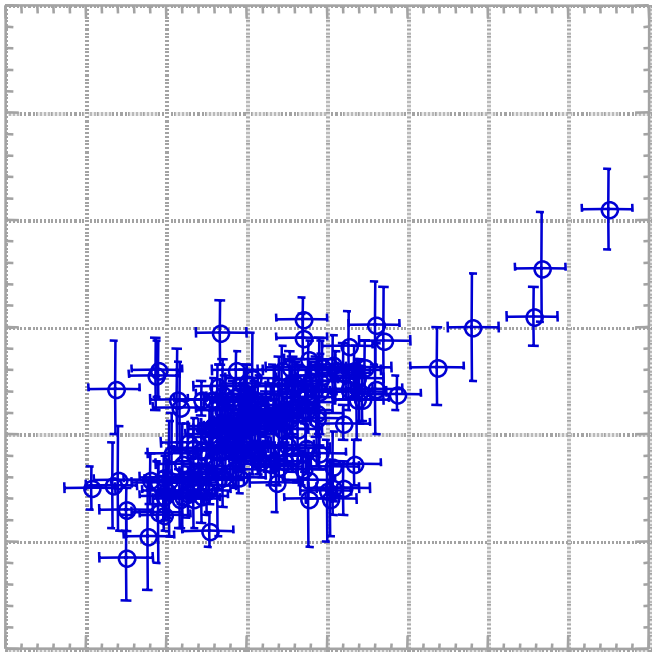
$$\sum_{i=1}^{N} F_i = 1$$

- These two equations utilize all 6 (non-thermal) TM bands.
- Constrained so that the sum of the fractions must equal 1.

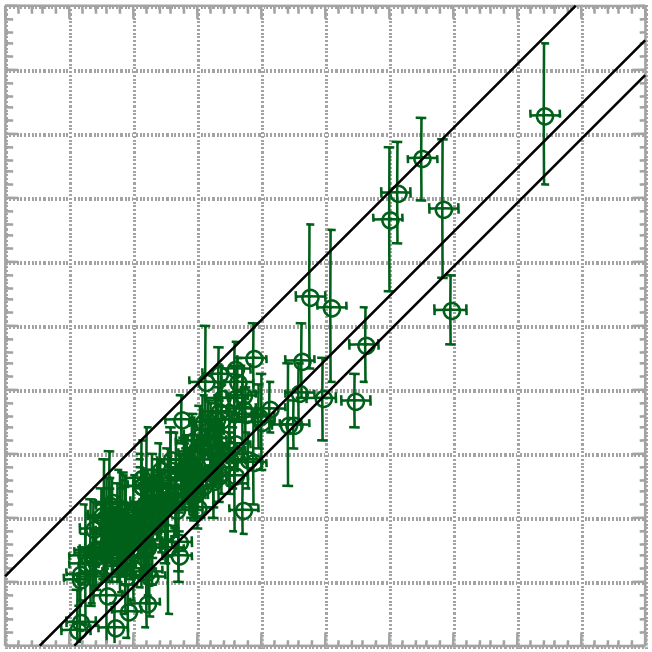


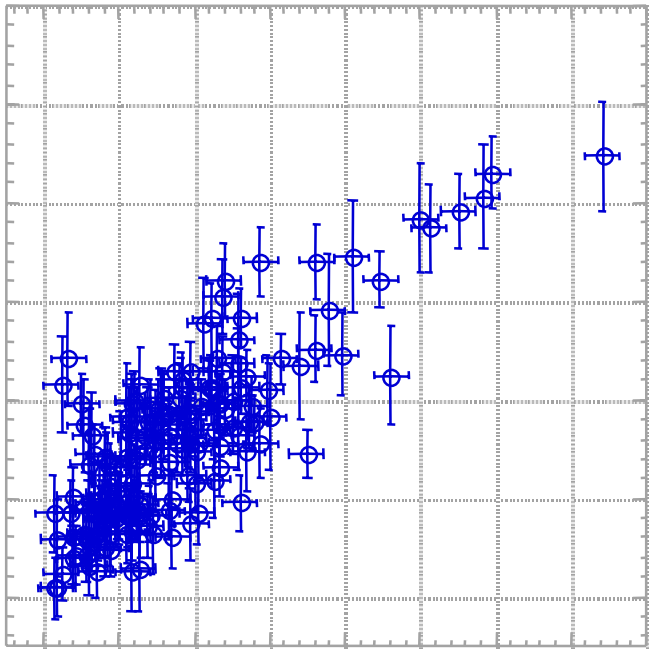
Absolute Abundance



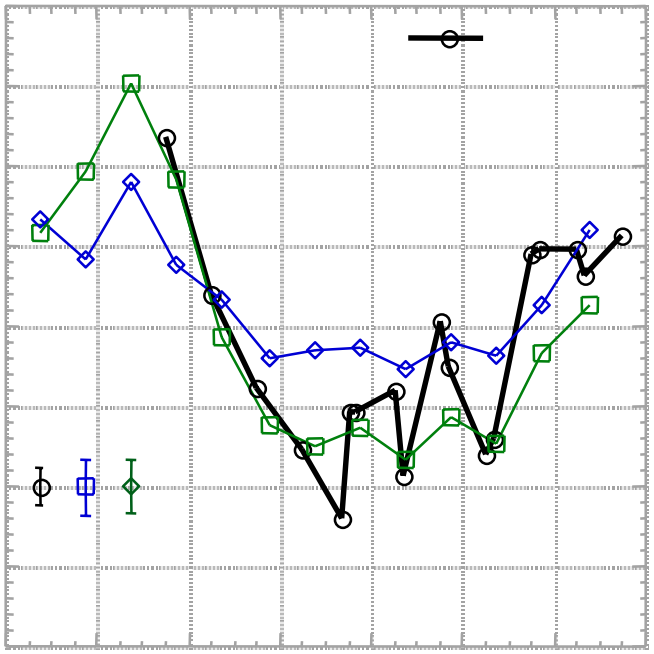


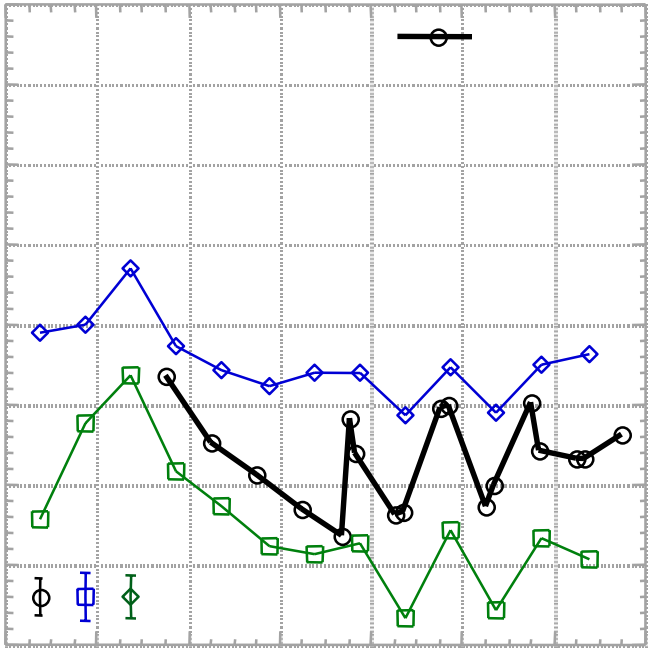
Normalized Abundance



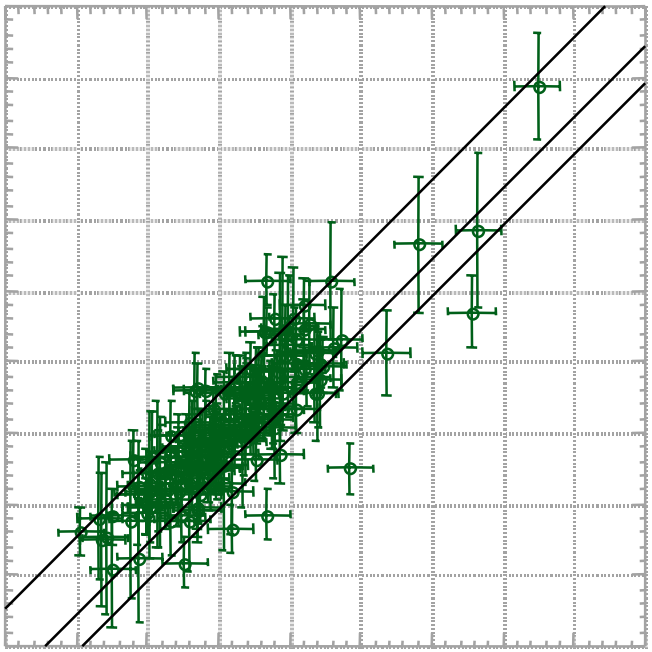


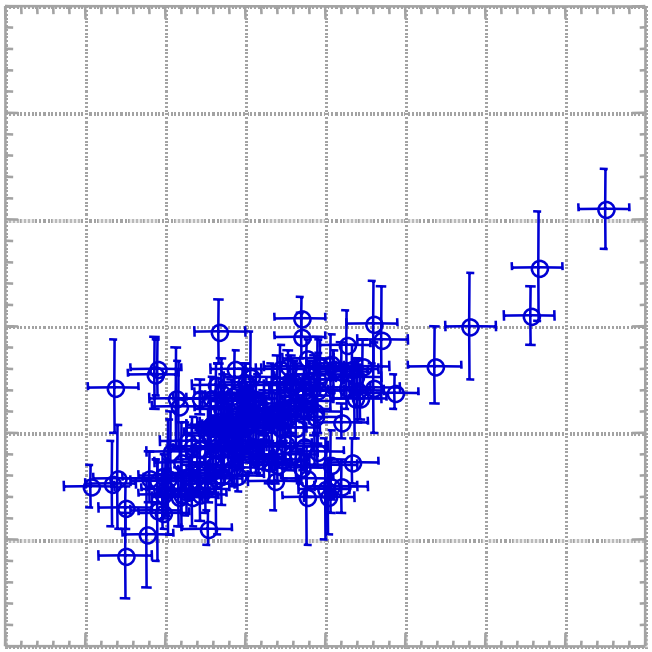
Field, SMA, and NDVI Data for Two Sites





Yearly Change in Abundance



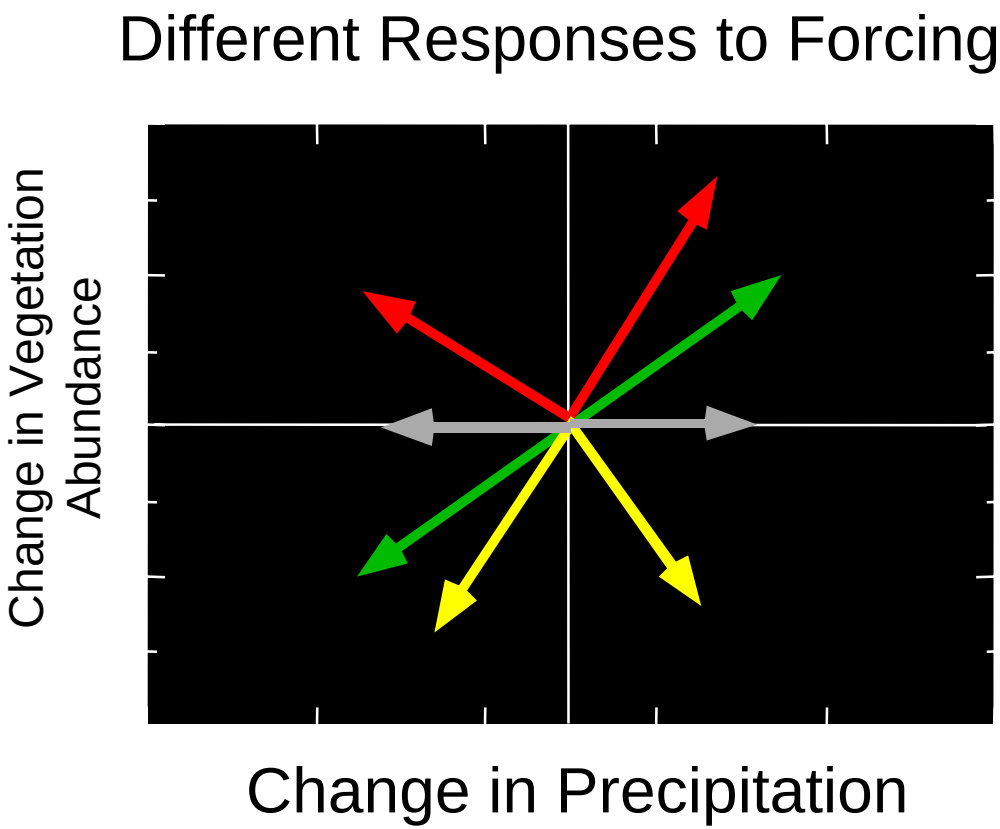


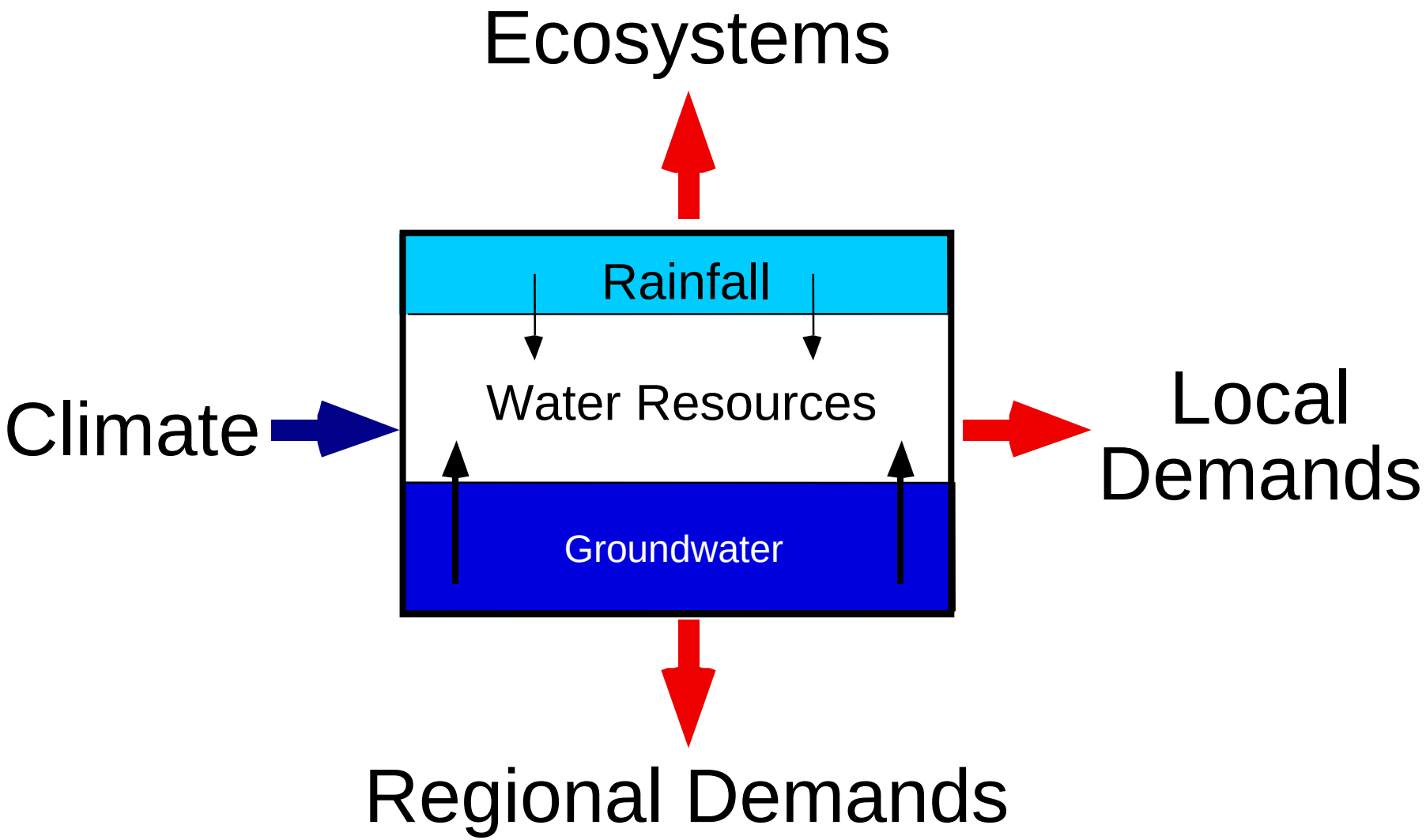
SMA Results

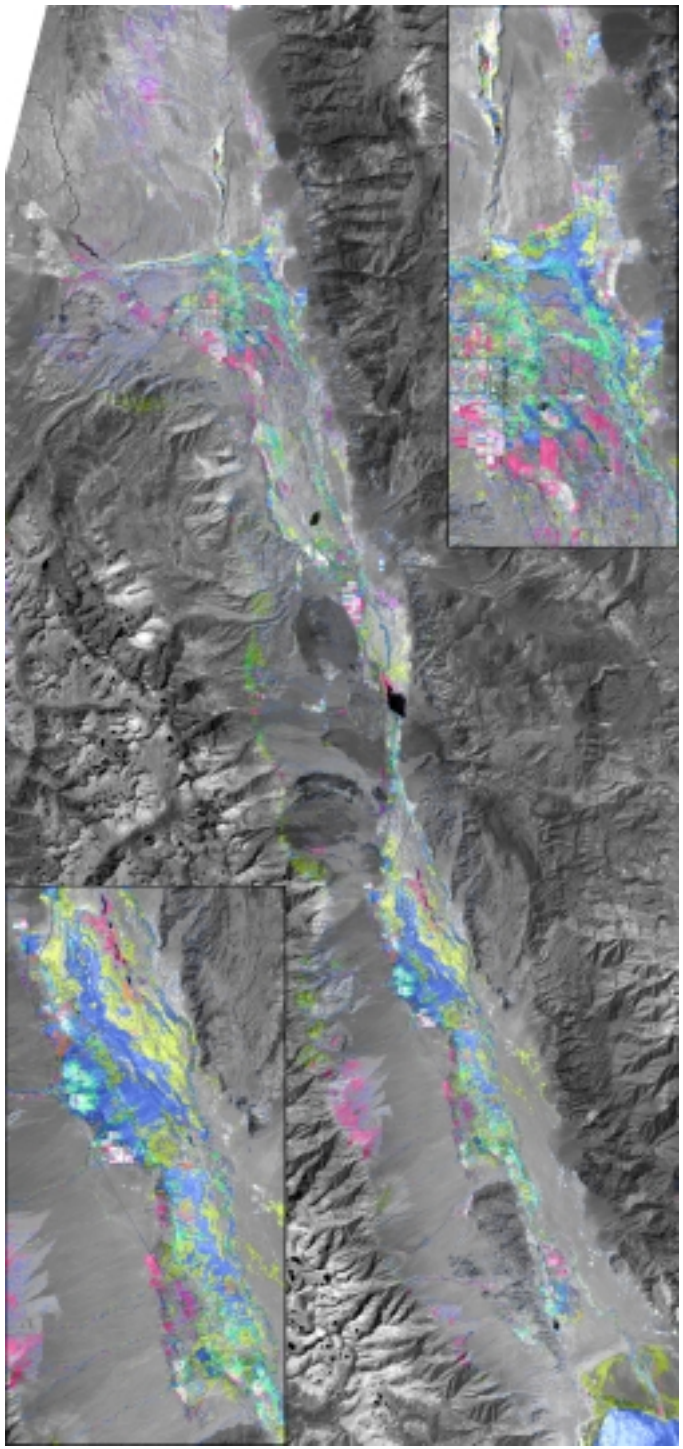
- SMA is linearly correlated with field measures of % live cover.
- Absolute % live cover accuracy +/- 4.0%
- Yearly change in % live cover precision +/- 3.8%
- SMA produces the correct sense of change in 86% of the data vs. 67% for NDVI.

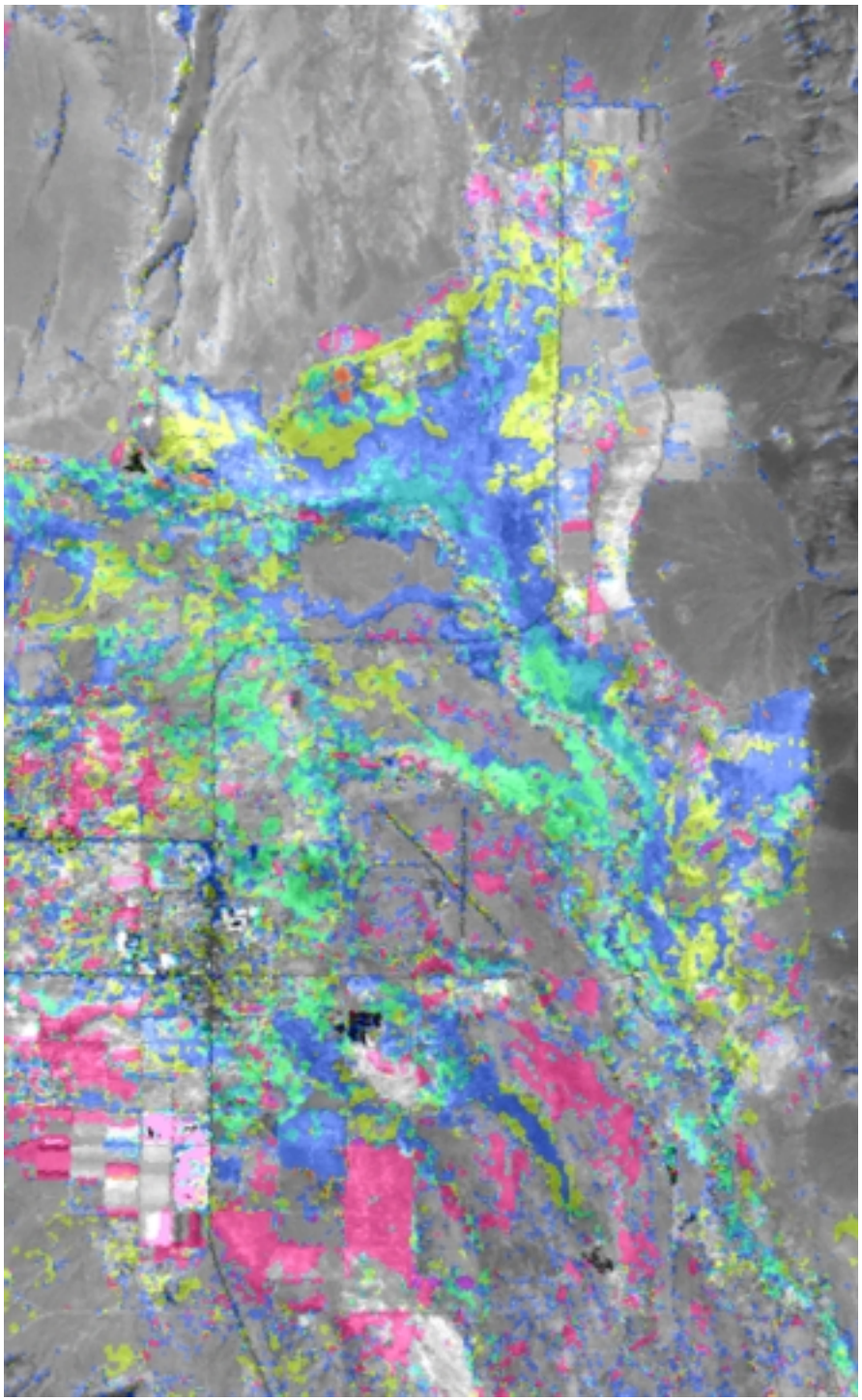
RESPONSE ANALYSIS

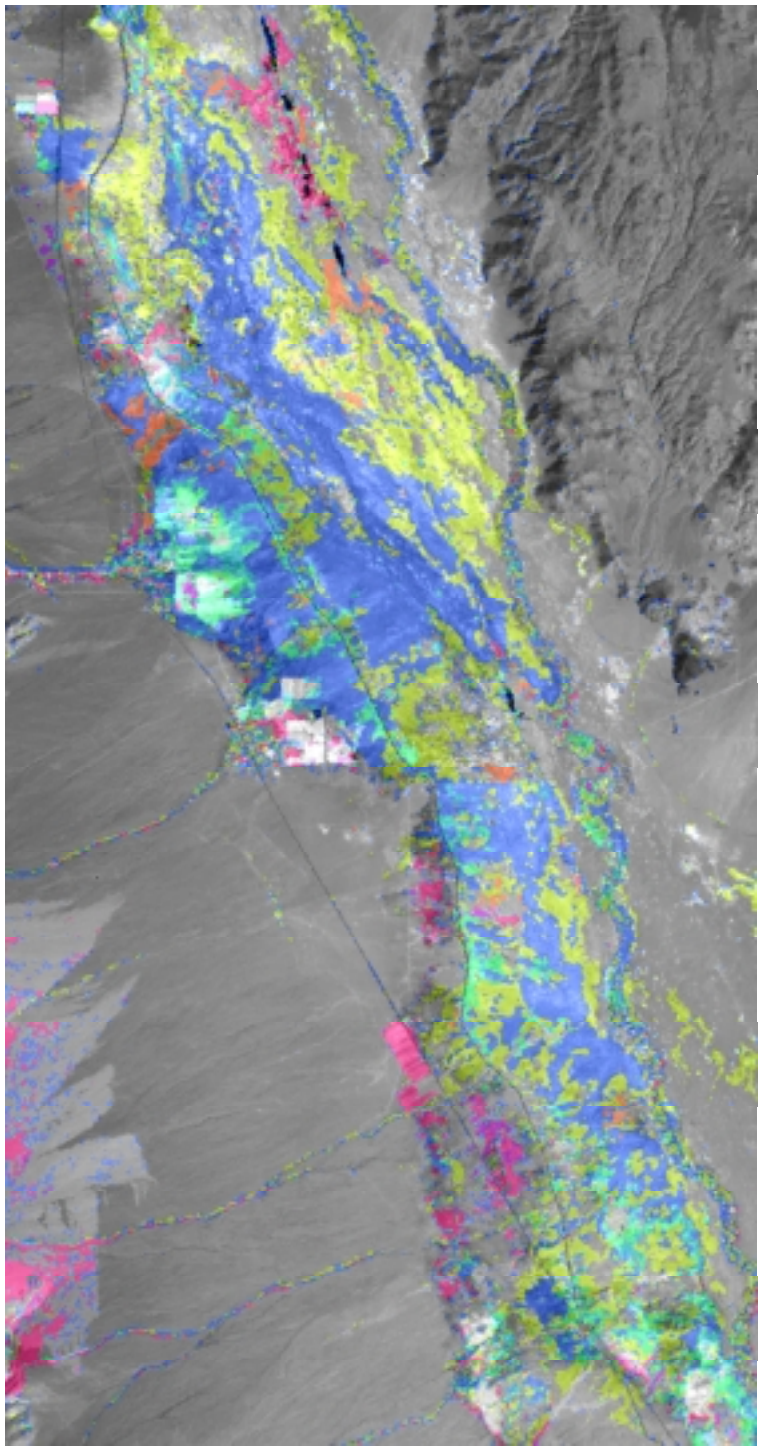
- Identify and map common modes of response from remotely sensed data
- Link common modes to the permanent monitoring sites and then to the key physiographic, land-use history, and water resource history
- Scale the detailed site analysis up to the regional perspective
- Bring analytical modeling in as a tool to relate observed patterns of change to water resource, ecosystem, and management issues


Different Responses to Forcing
Change in Vegetation Abundance
Change in Precipitation


Ecosystems
Rainfall
Climate
Water Resources
Local
Demands
Groundwater
Regional Demands







LAND-USE HISTORY

- What is the effect of prior land use on response?
- What is a successional model for semi-arid systems?
- Key stages of land use have been documented:
  - Pre-1900
  - 1926 detailed land use maps
  - Aerial photography 1944, 1969, 1983
- Preliminary work to define history for 3 type localities

PROJECT STATUS

- Progress is about where we anticipated we'd be at this stage
- Detailed validation and verification of mixture model and remote sensing was required to accommodate the needs of LADWP
- Response analysis is beginning and indicates extraordinary levels of information
- Completion of entire project to the level of full publication of results will extend beyond the formal end date