

Do Forest Treatments Improve Tree Vitality Under Drought?

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UC Davis

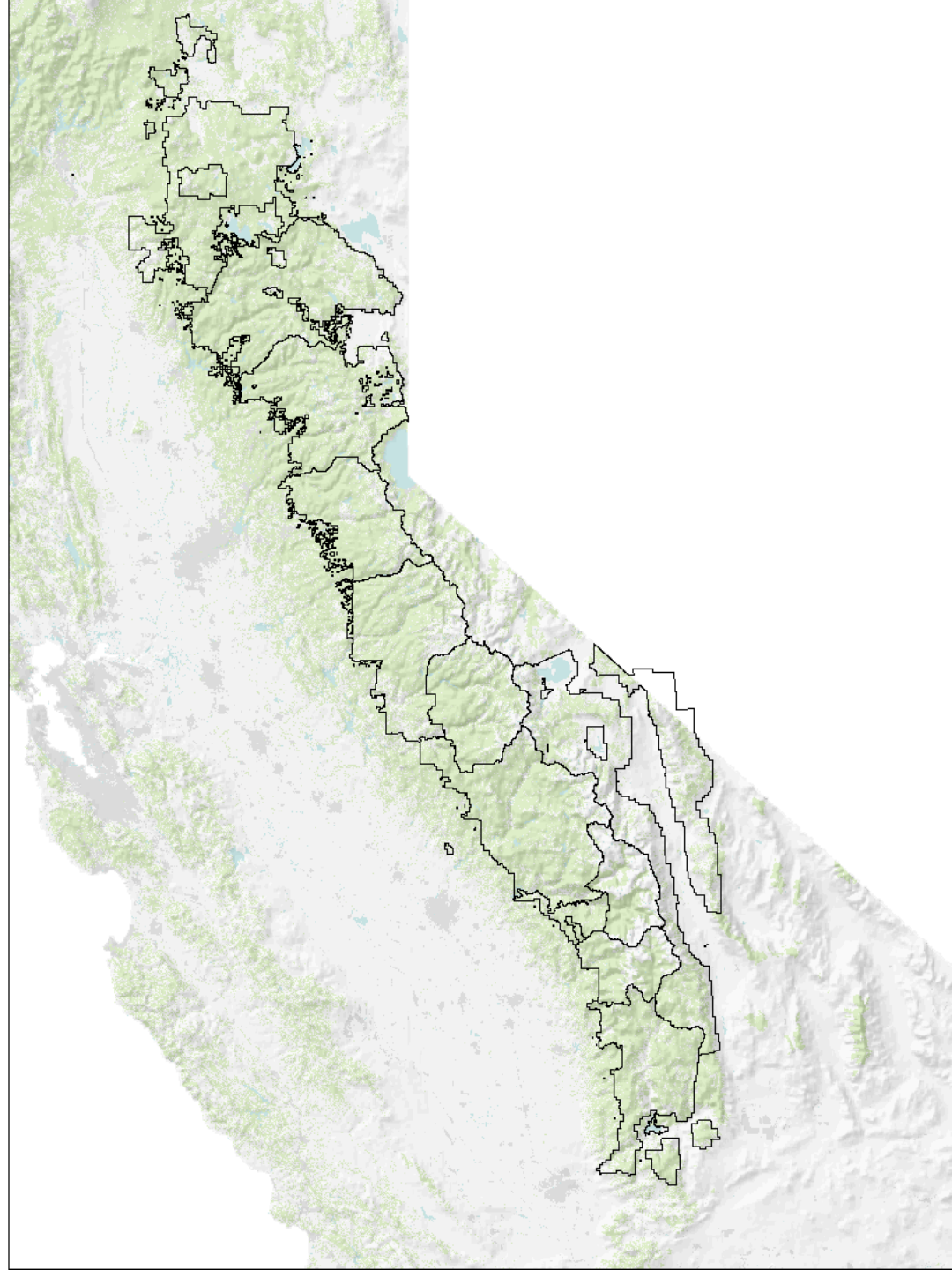
Phil van Mantgem, Adrian Das, Nate Stephenson, Carlos Ramirez, Hugh Safford
USGS, USFS

Funding: USGS Southwest Climate Science Center

Credit: N. Stephenson

Purpose of Project

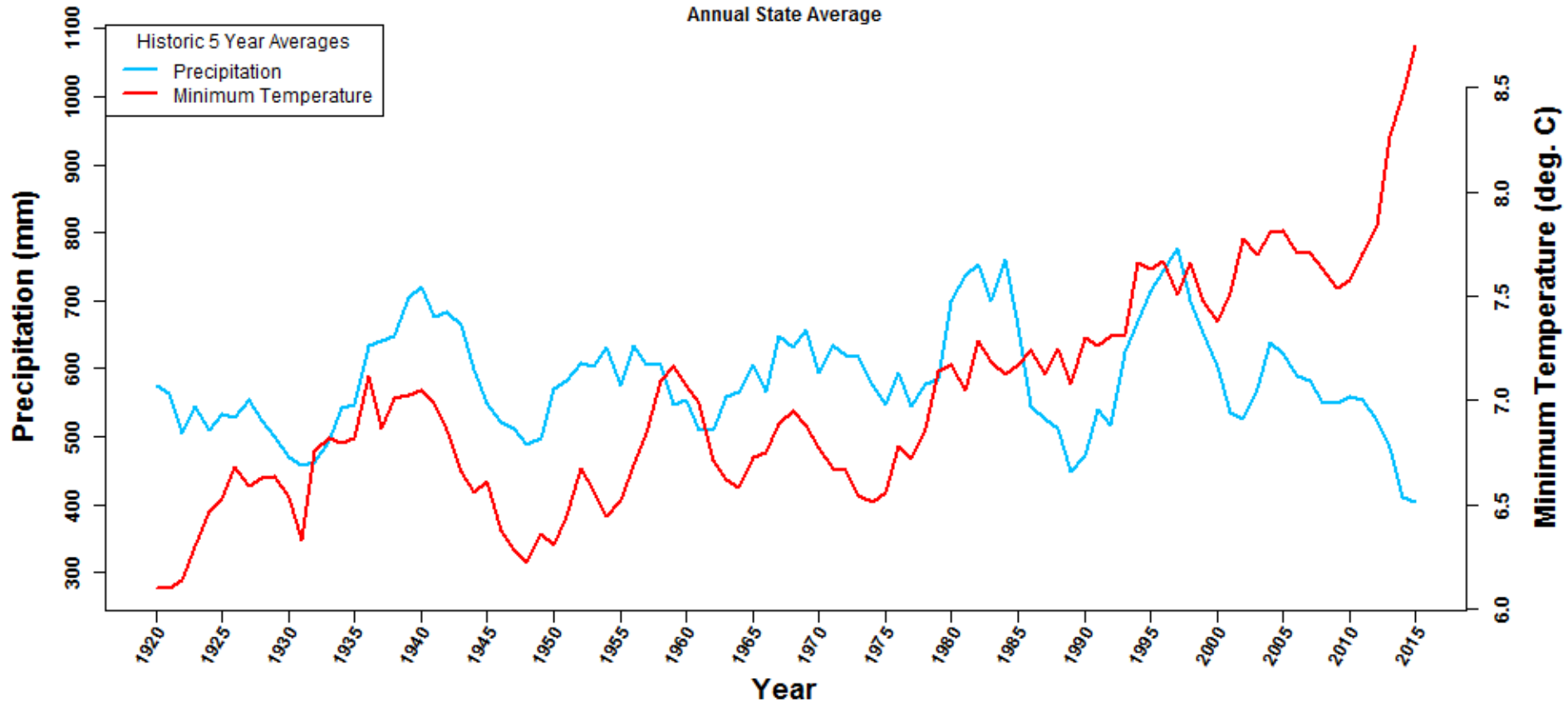
To use current drought as an experiment to see if forest treatments in the Sierra Nevada have “healthier” trees than areas that have not been treated.



Annual Average Precipitation and Temperature for California

Precipitation & Minimum Temperature

Annual State Average



Project Parts

Plot Data

Historical Plot Data

Targeted Project Plot Data

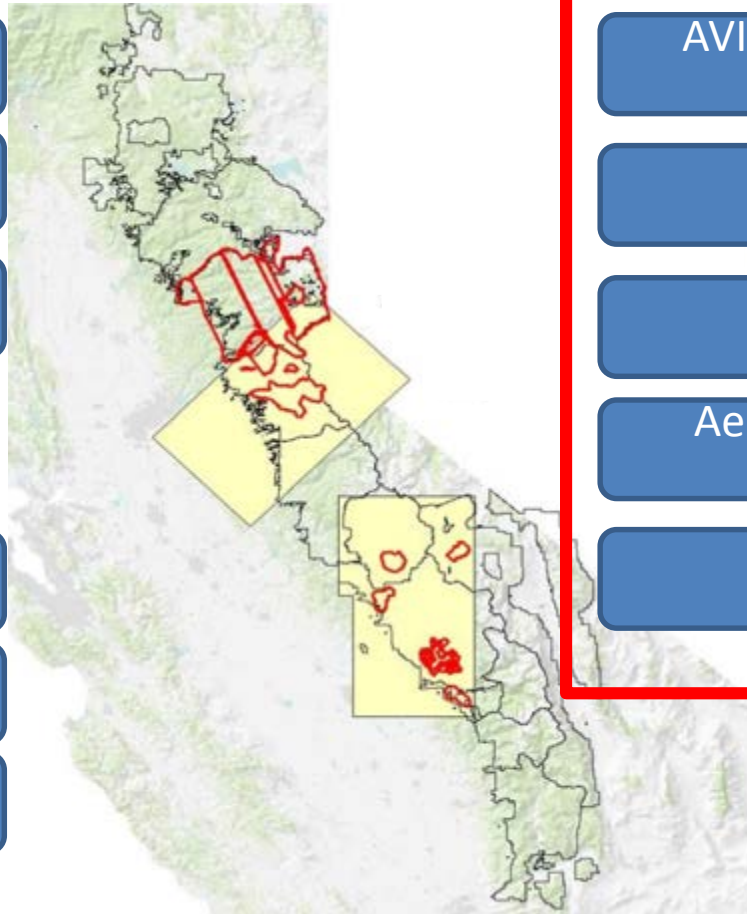
Experimental Plots

Leaf Data

Leaf Water Content

Leaf Spectra

Water pressure



Remote Sensing

AVIRIS (224 bands X 4 years)

LIDAR

LandSat

Aerial Tree Mortality Surveys

MODIS

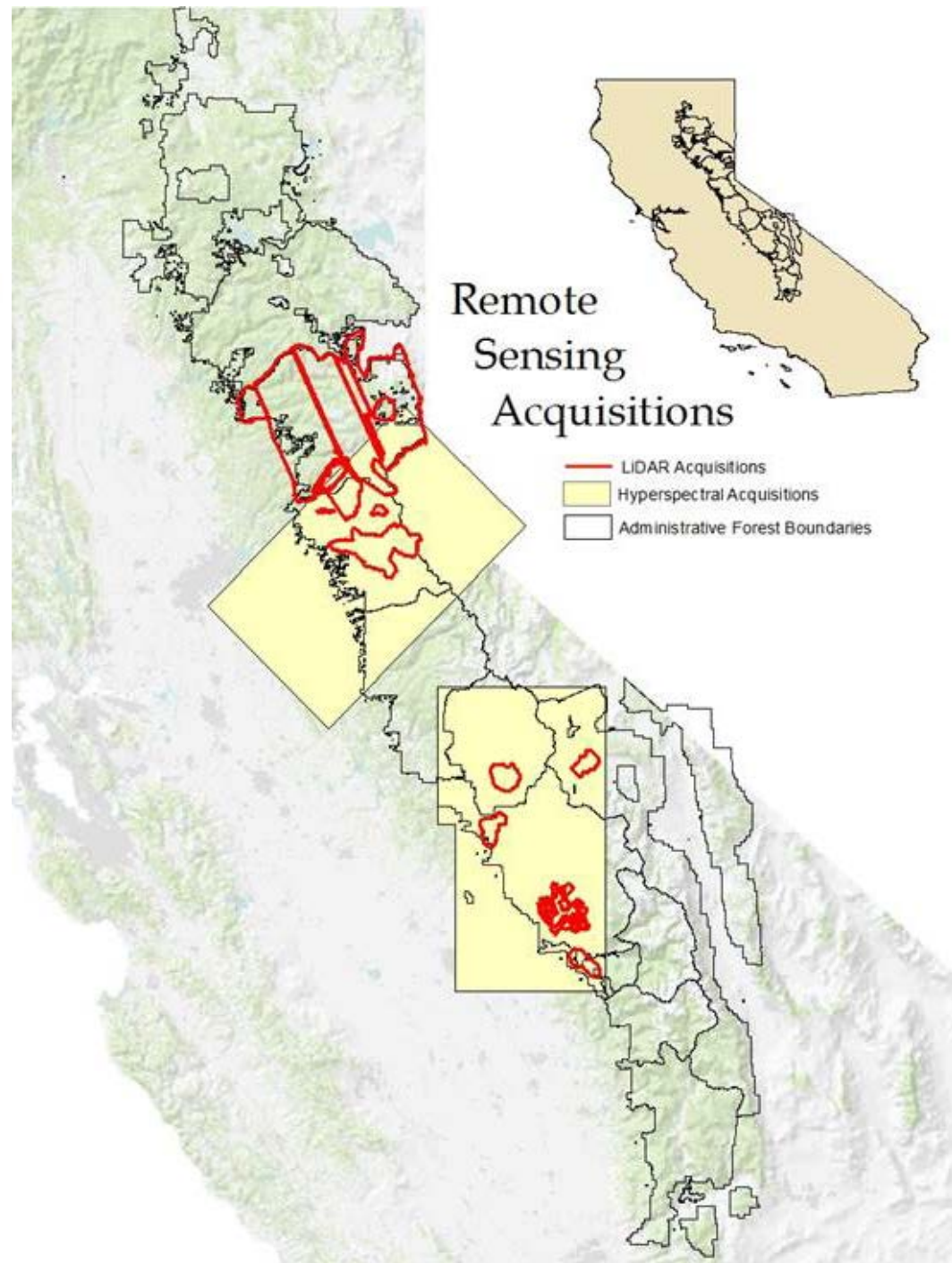
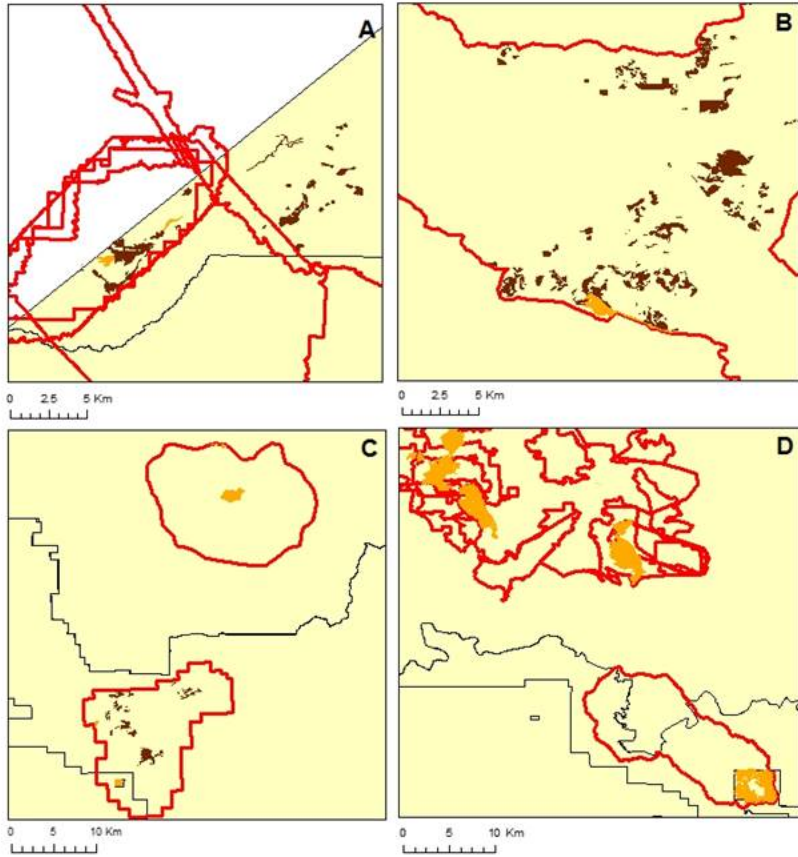
GIS DATA

Stand Treatments – prescribed burn (perimeters), thinning, combination, other

Climate Data & models – PPT, Tmin, Tmax, CWD, Snow, Recharge, Runoff

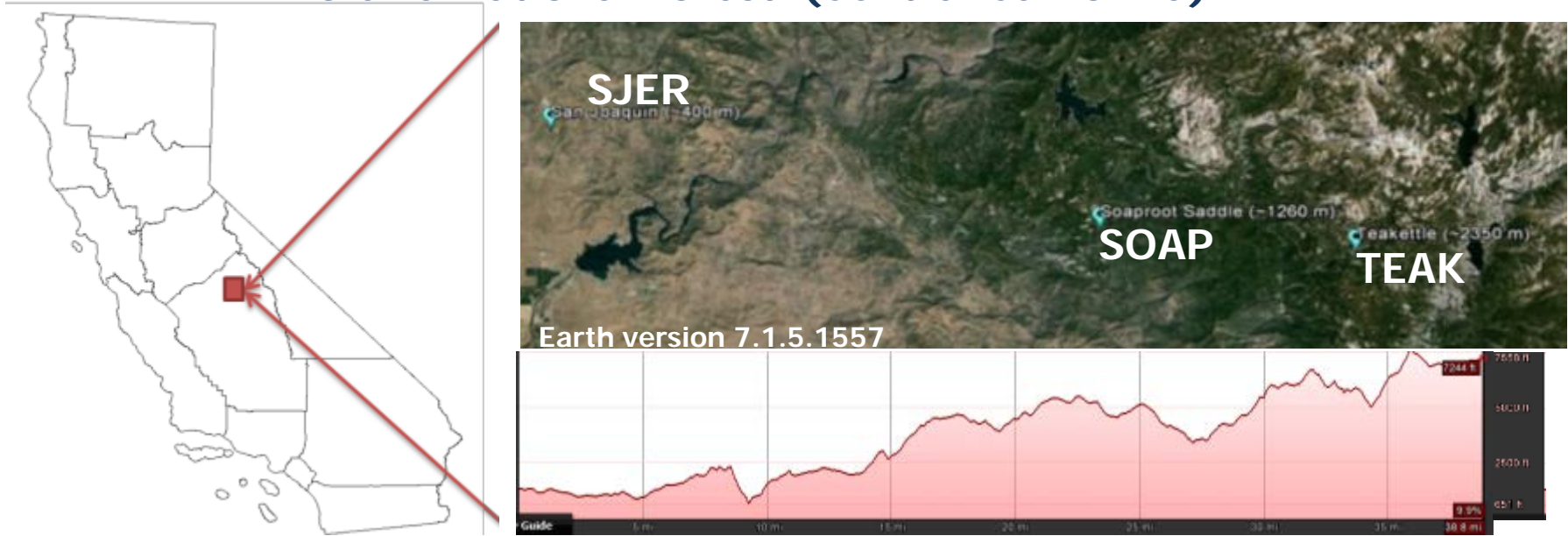
Environmental Data – topographic roughness, aspect, slope, geology, landcover, etc.

Areas of LiDAR, Prescribed Fire, and Thinning



Local-Level Approach

Sierra National Forest (Central California)

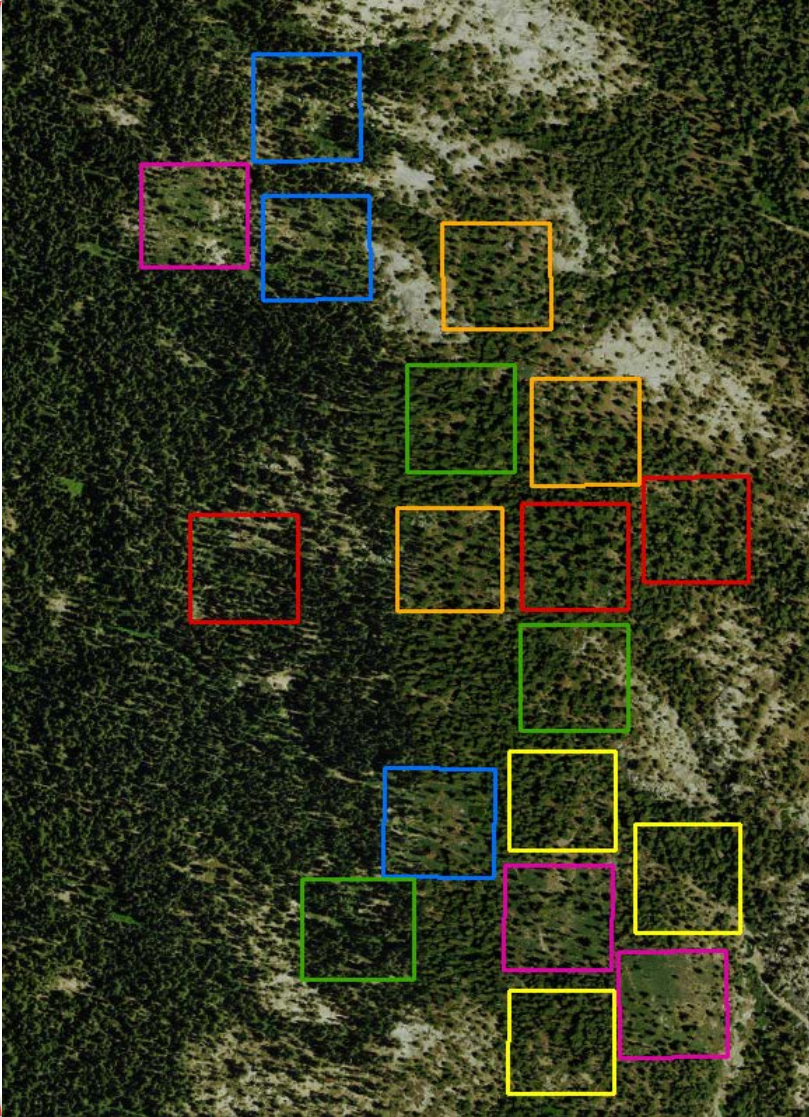








San Joaquin Experimental Range (SJER): Low elevation. Open woodland Savana dominated by *Quercus douglasii*, *Quercus wislizeni*, and *Pinus sabiniana*.

Soaproot Saddle (SOAP): Mid elevation. Mixed conifer and broadleaf forest dominated by *Quercus kelloggii*, *Quercus chrysolepsis*, *Pinus lambertiana*, and *Pinus ponderosa*.

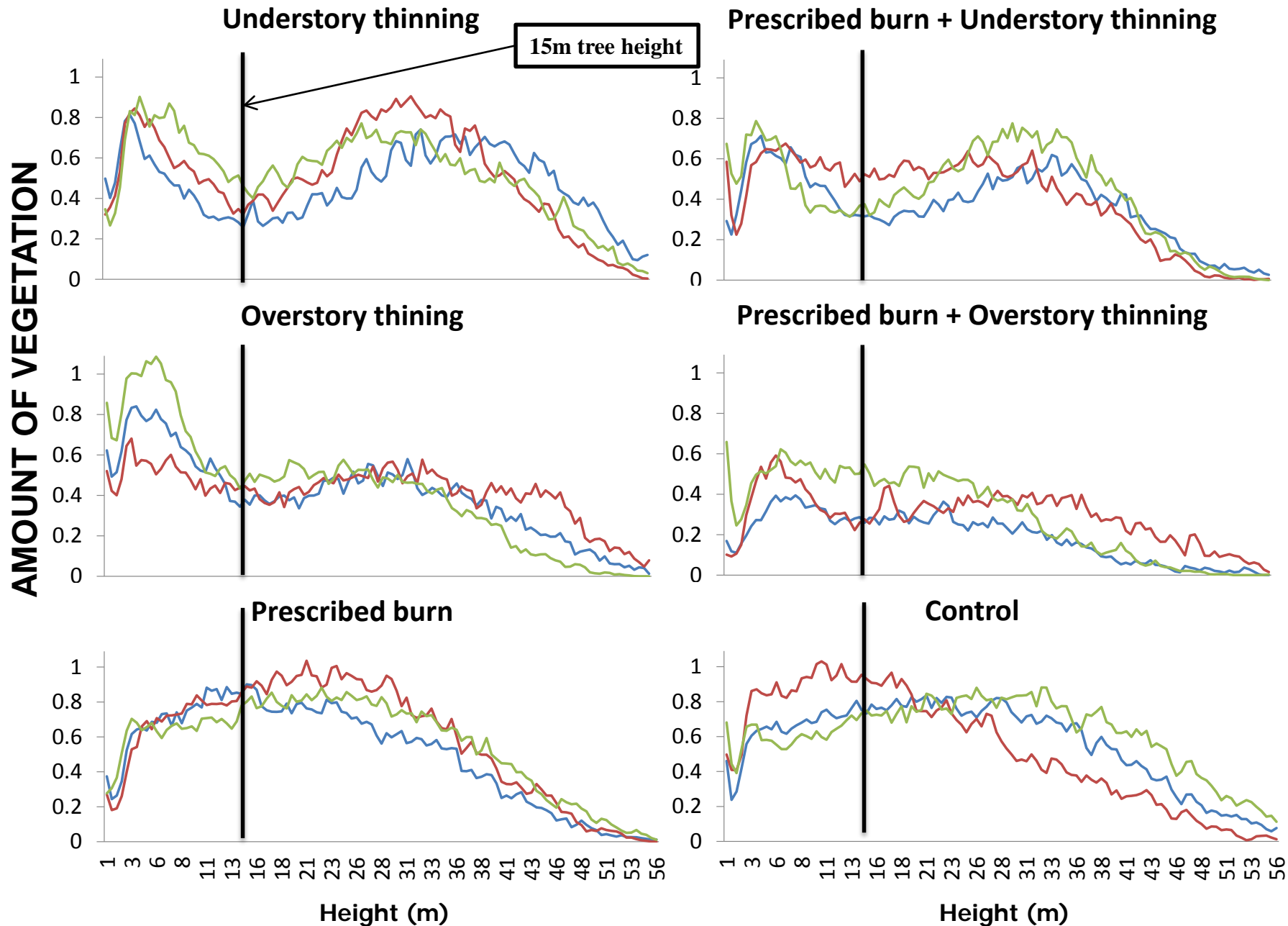
Teakettle Experimental Forest (TEAK): High elevation. Old-growth conifer forest dominated by *Abies concolor*, *Abies magnifica*, and *Pinus jeffreyi*.

Teakettle Experimental Forest



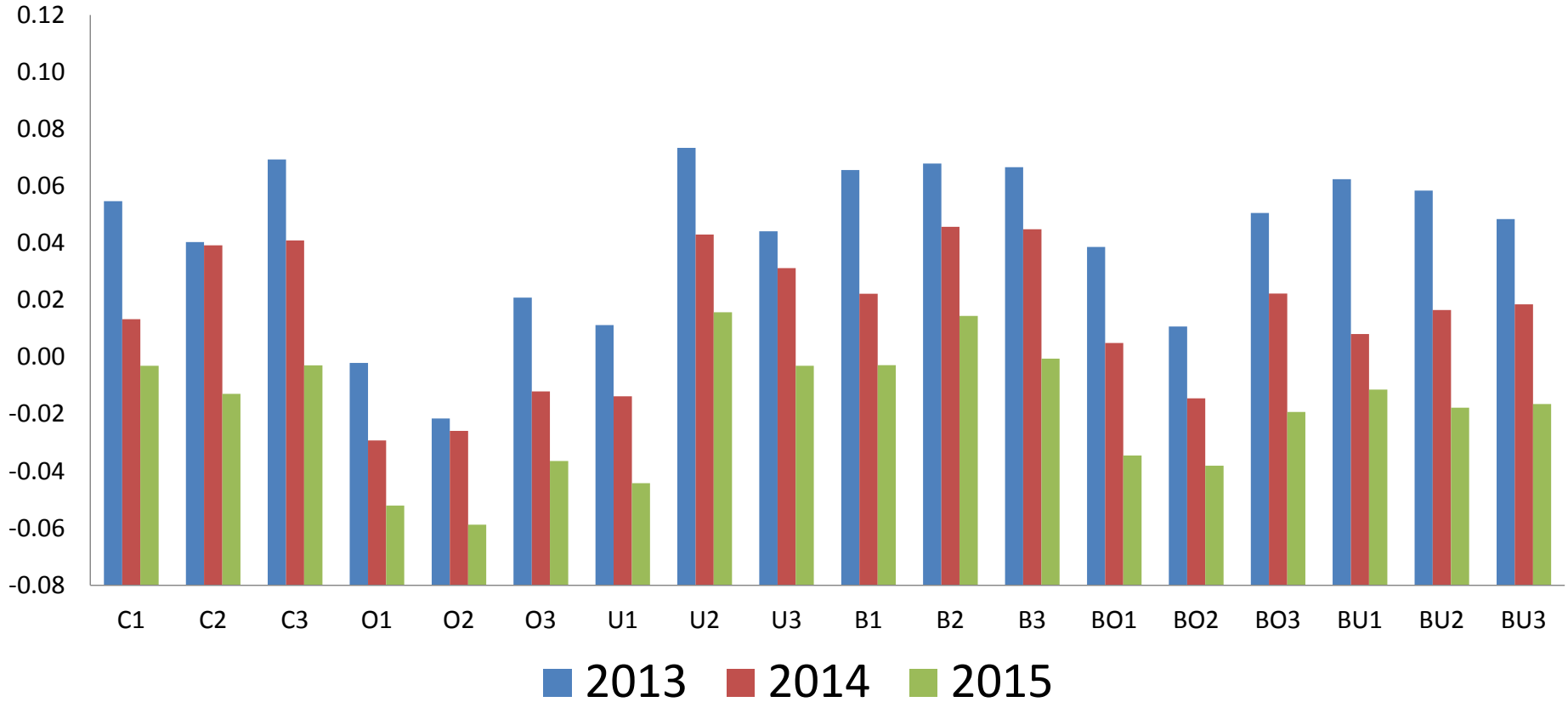
-  BU: burned + understory thinning
-  B: Burned
-  BO: Burned + overstory thinning
-  U: Understory thinning
-  C: control
-  O: Overstory thinning

Vegetation Vertical Profile from LiDAR



Can forest management improve forest resilient to drought?

NDWI



BU: burned + understory thinning

B: Burned

BO: Burned + overstory thinning

U: Understory thinning

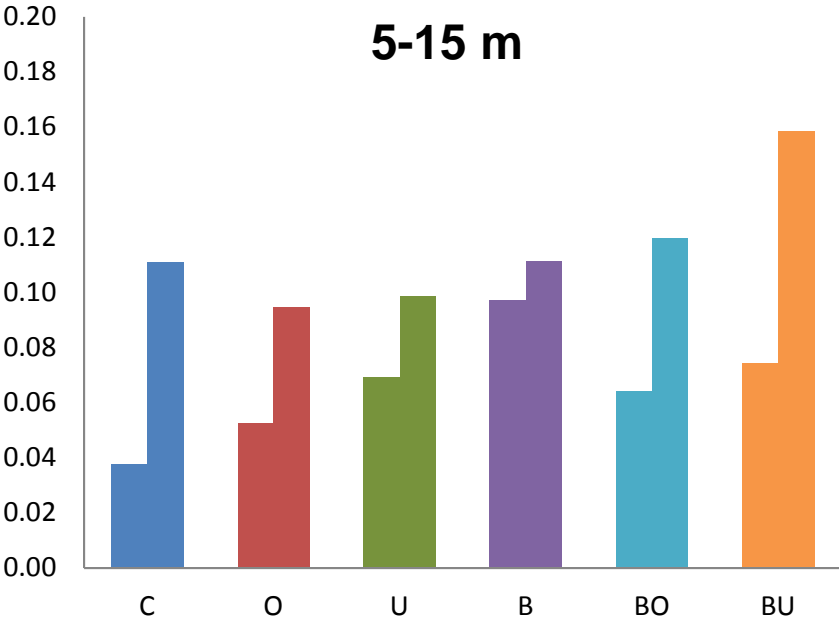
C: control

O: Overstory thinning

Can forest management improve forest resilient to drought?

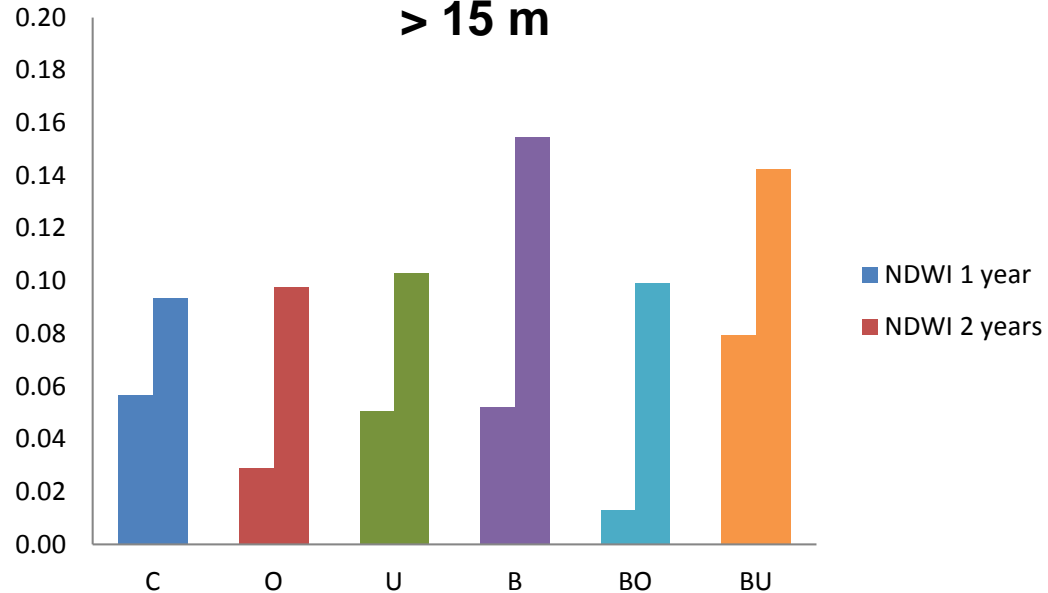
NDWI - young trees

5-15 m



NDWI- mature trees

> 15 m



BU: burned + under-story thinning

B: burned

BO: burned + over-story thinning

U: under-story thinning

C: control

O: over-story thinning

Temporal Sequence of Canopy Water Content NDWI

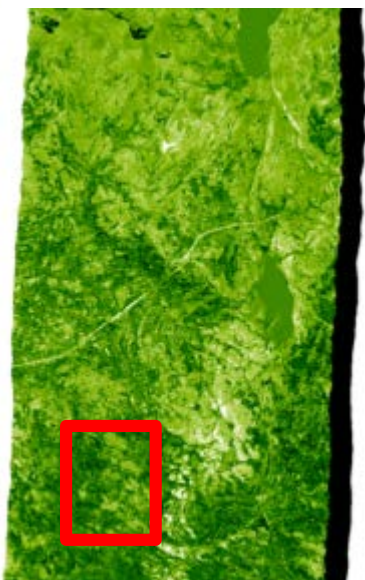
High elevation conifer forest

2013

2014

2015

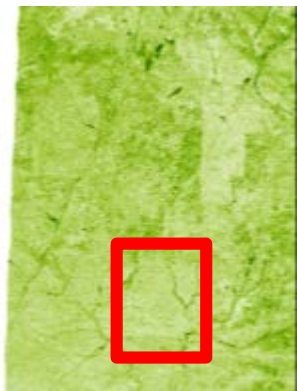
18 Km



Canopy
Water
Content
Decrease

2013-
2015

10 Km



Oak savanna woodland

High

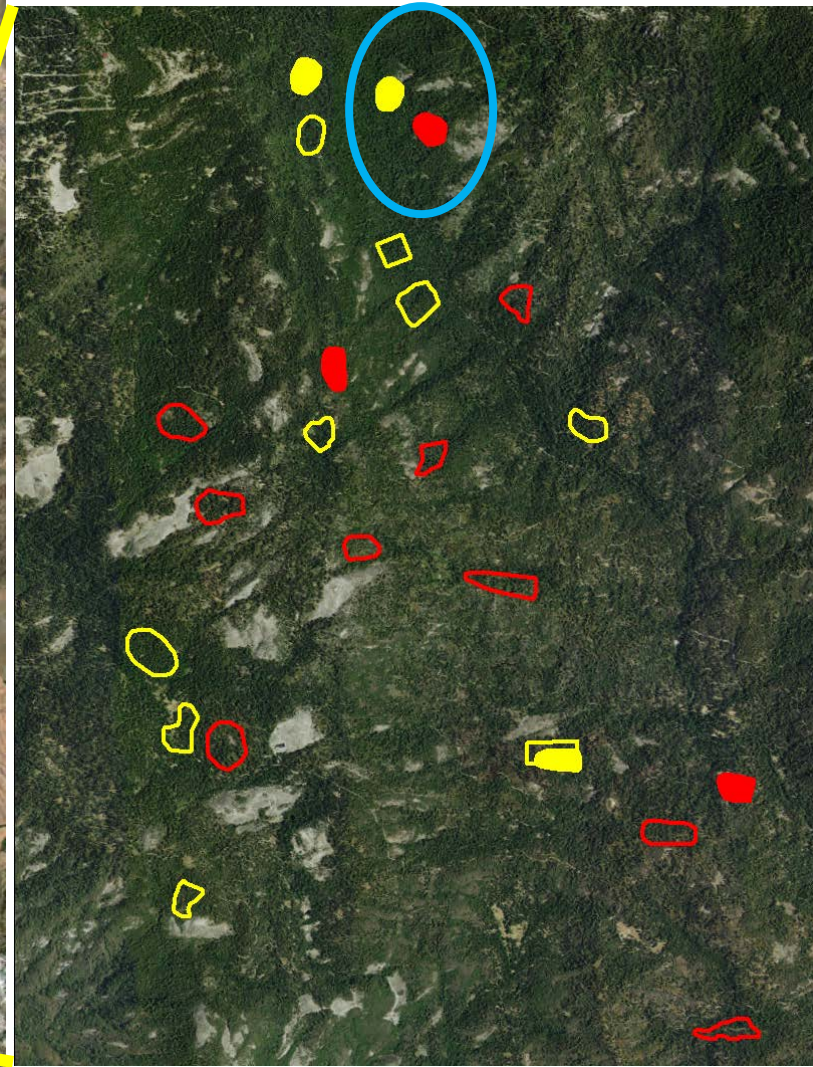
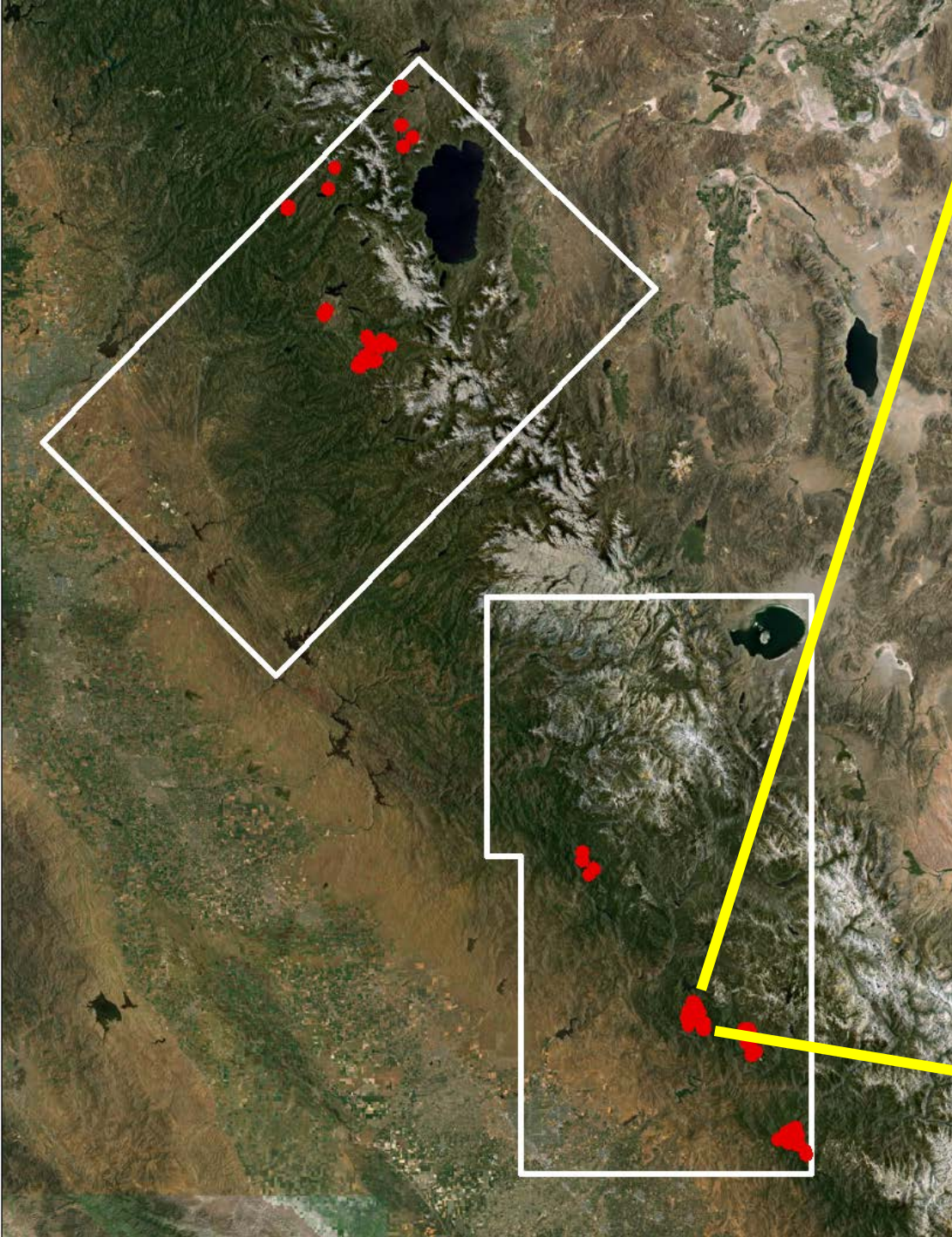


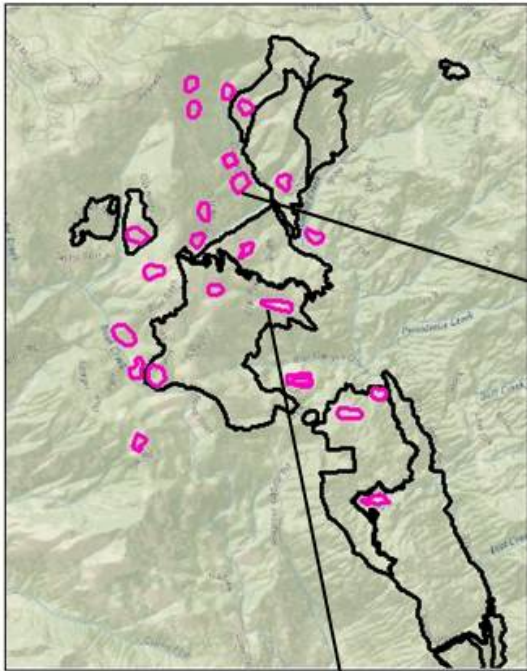
Low



High

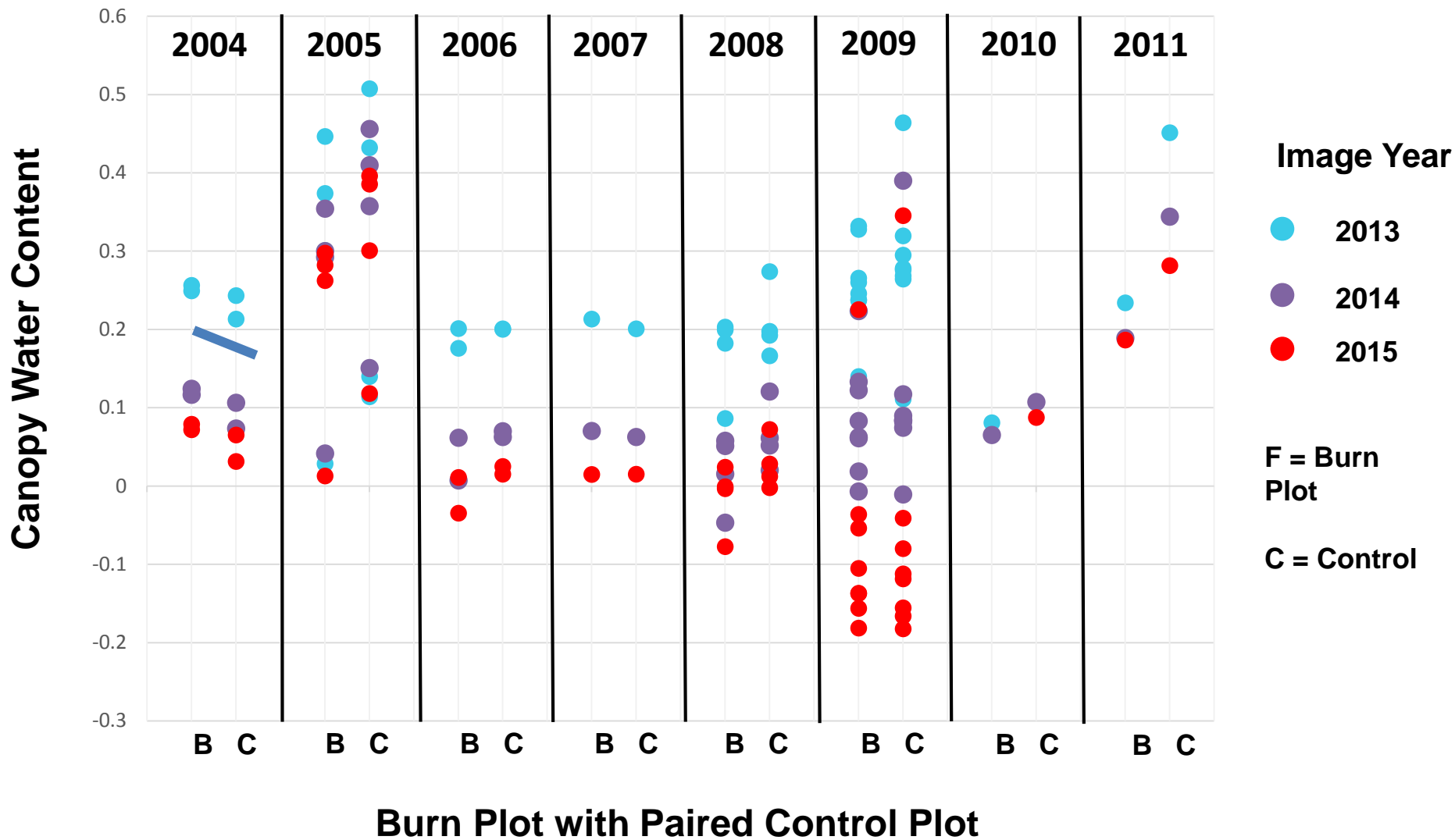
Meso-Level Approach



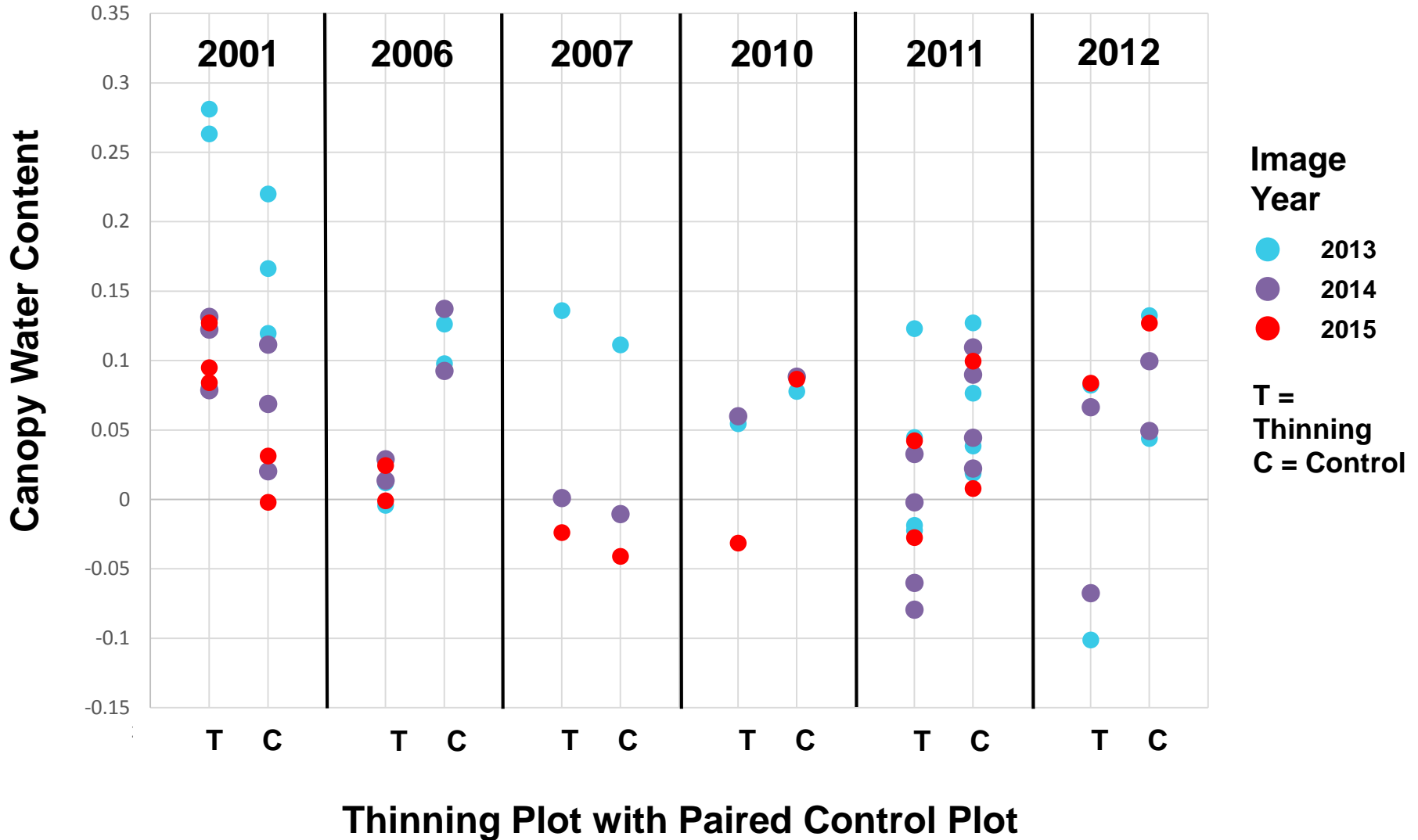


Sierra National
Forest Paired
Prescribed
Fire Plots

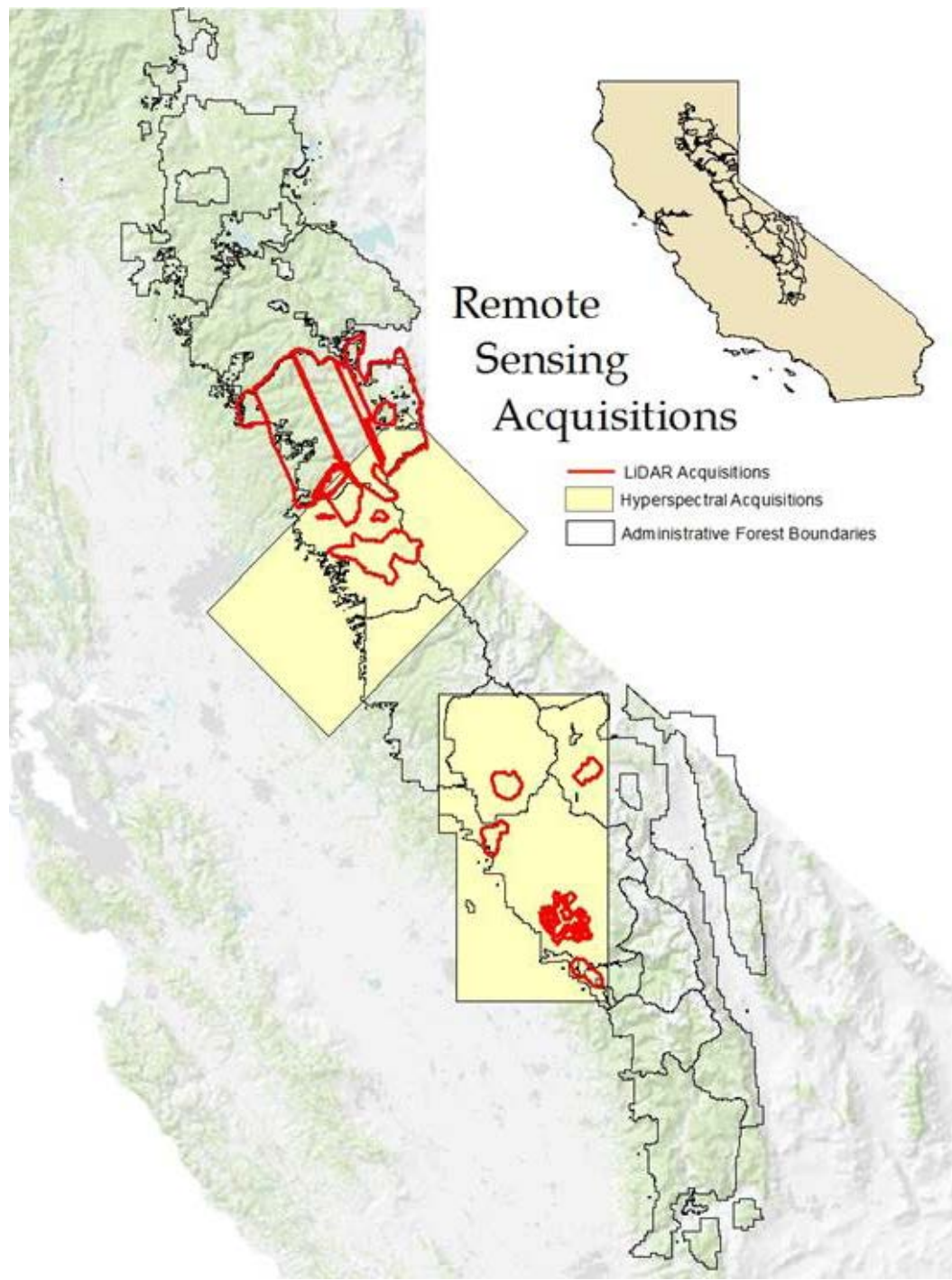
Change in Canopy Water Content Across 2013-2015 for Prescribed Burn Treatments



Change in Canopy Water Content Across 2013-2015 for Thinning Treatments

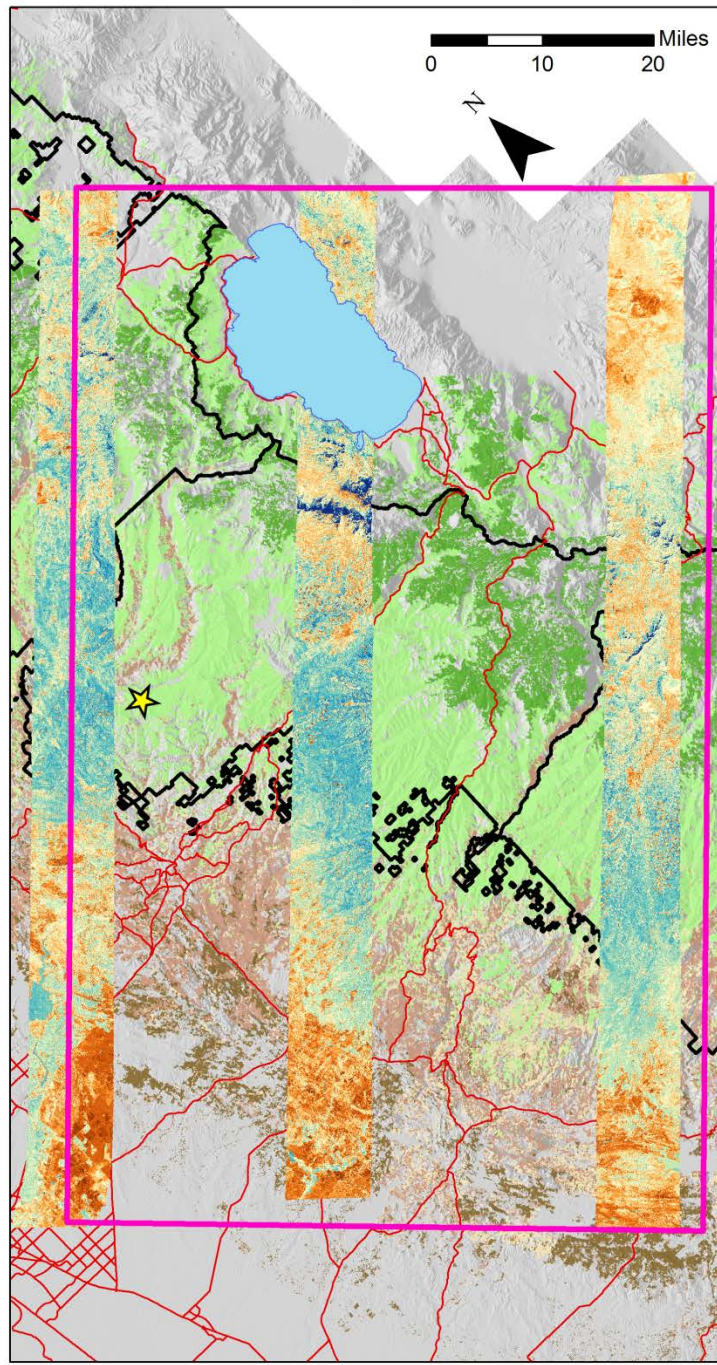
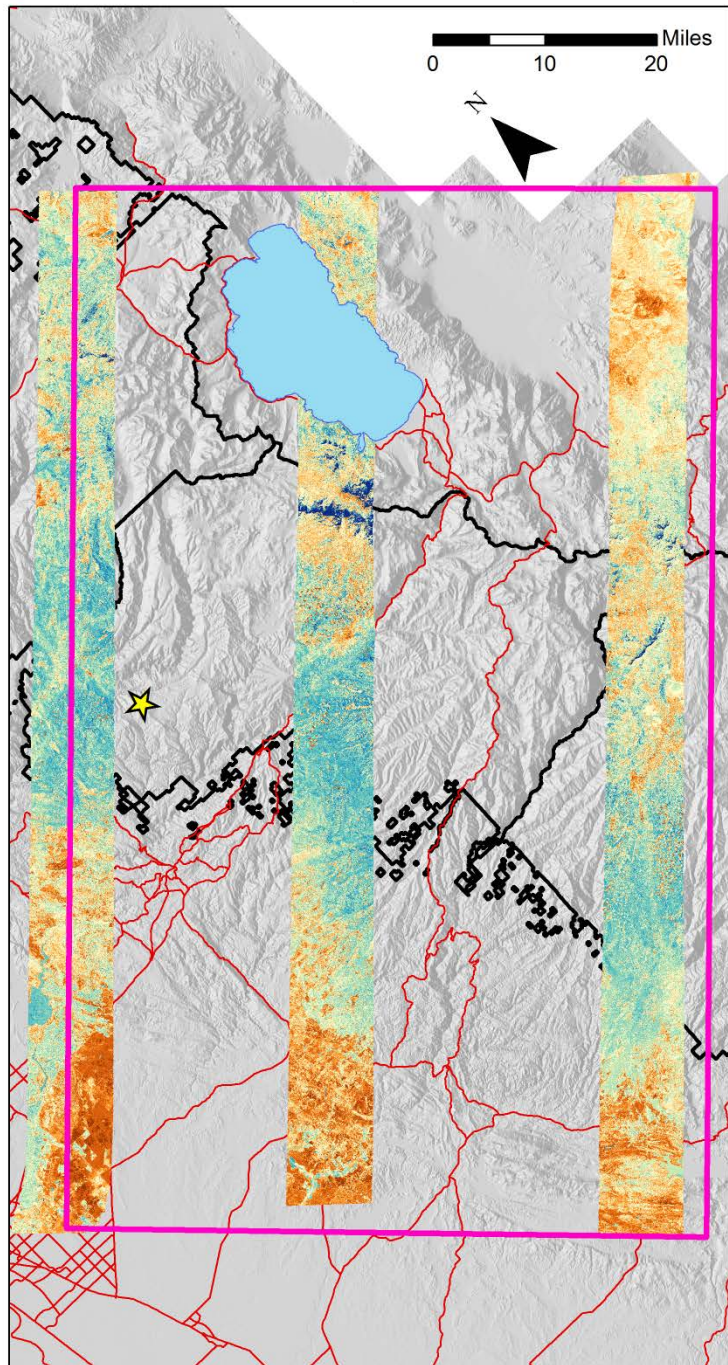


Landscape-Level Approach

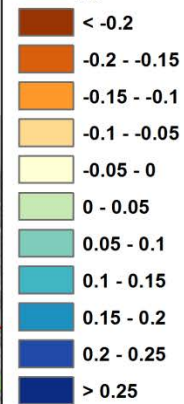


2013 Canopy Water Index

2013 Canopy Water Index



Canopy Water Index



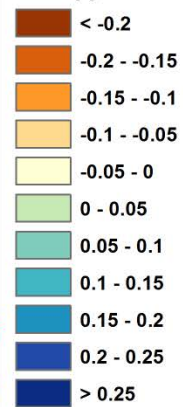
Habitat Band



2014 Canopy Water Index

2015 Canopy Water Index

Canopy Water Index



Habitat Band



- ★ 2016 Plot Visits
- Hyperspectral Extent
- USFS Boundary
- Lake Tahoe
- Major Roads



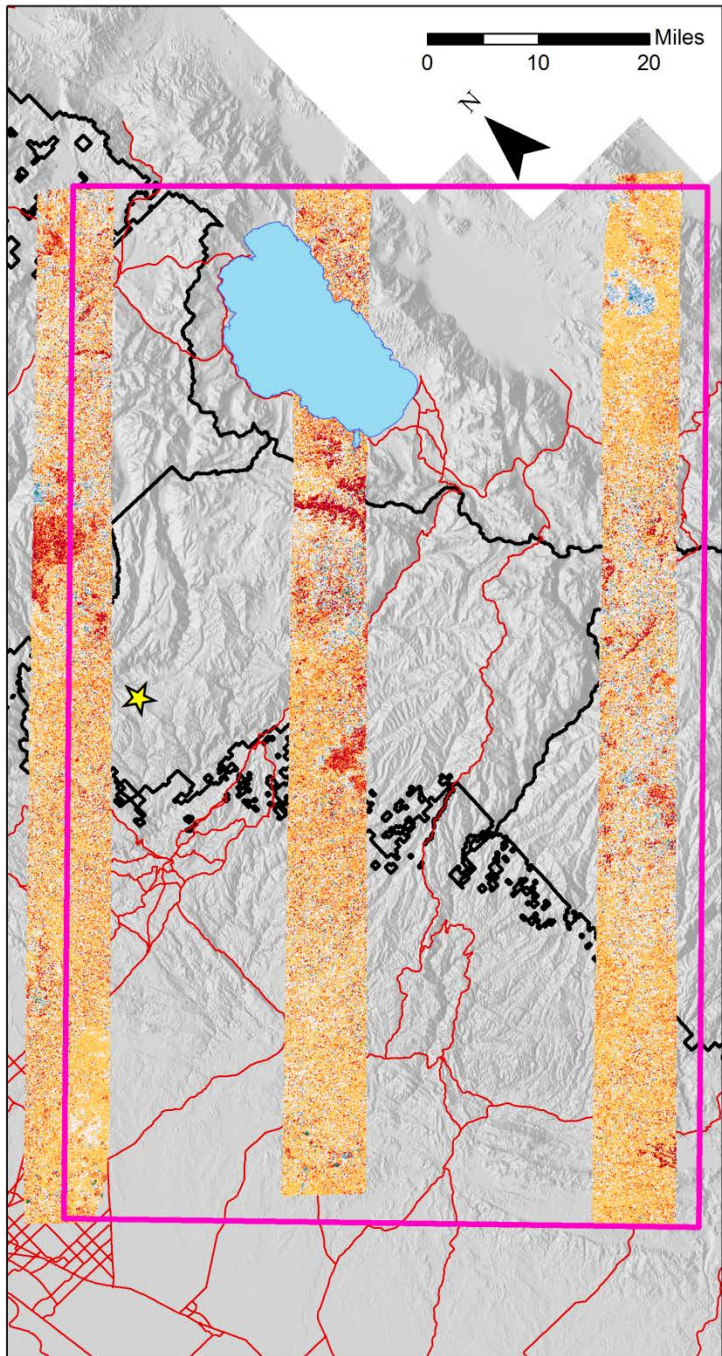
0 10 20 Miles



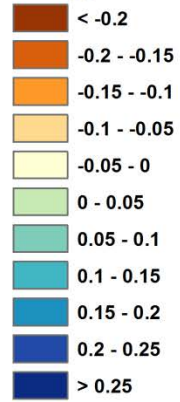
0 10 20 Miles



Change in Canopy Water Index: 2013 to 2015



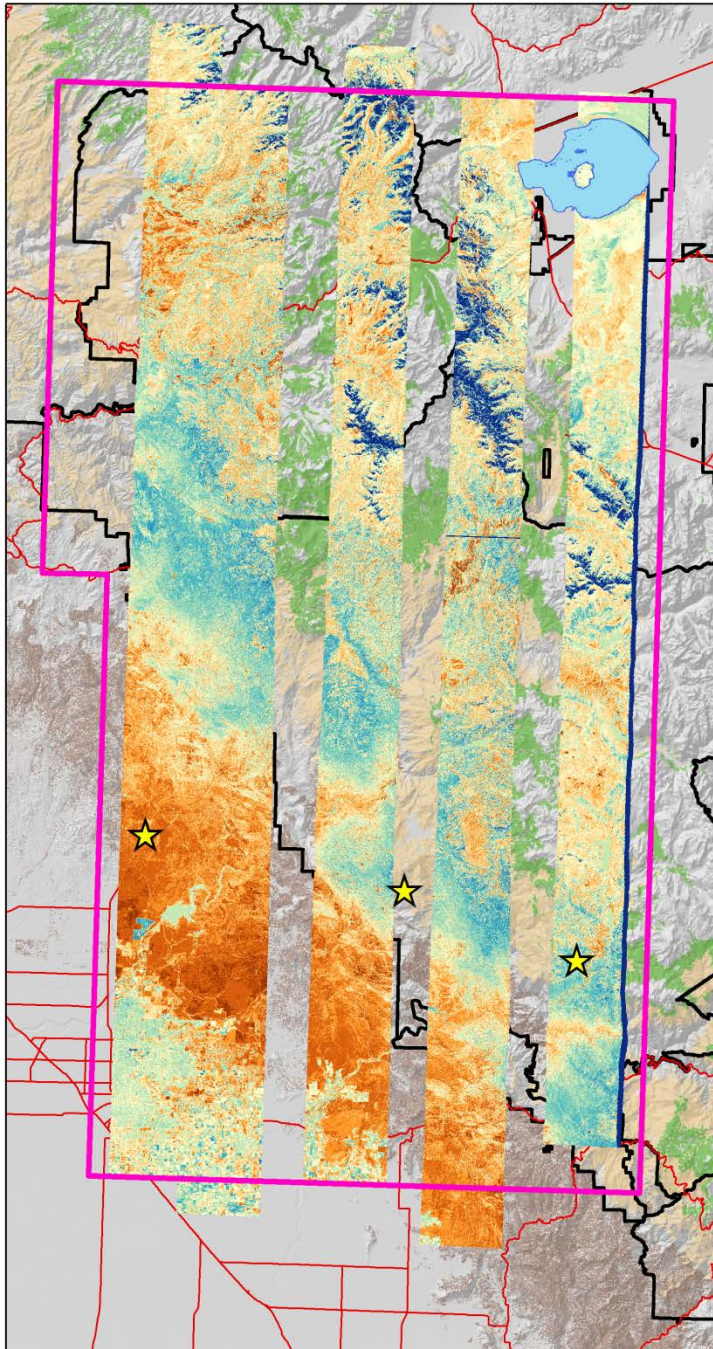
Canopy Water Index



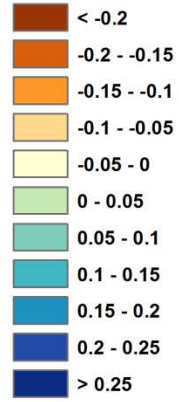
- ★ 2016 Plot Visits
- Hyperspectral Extent
- USFS Boundary
- Lake Tahoe
- Major Roads



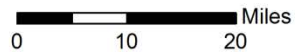
2014 Canopy Water Index



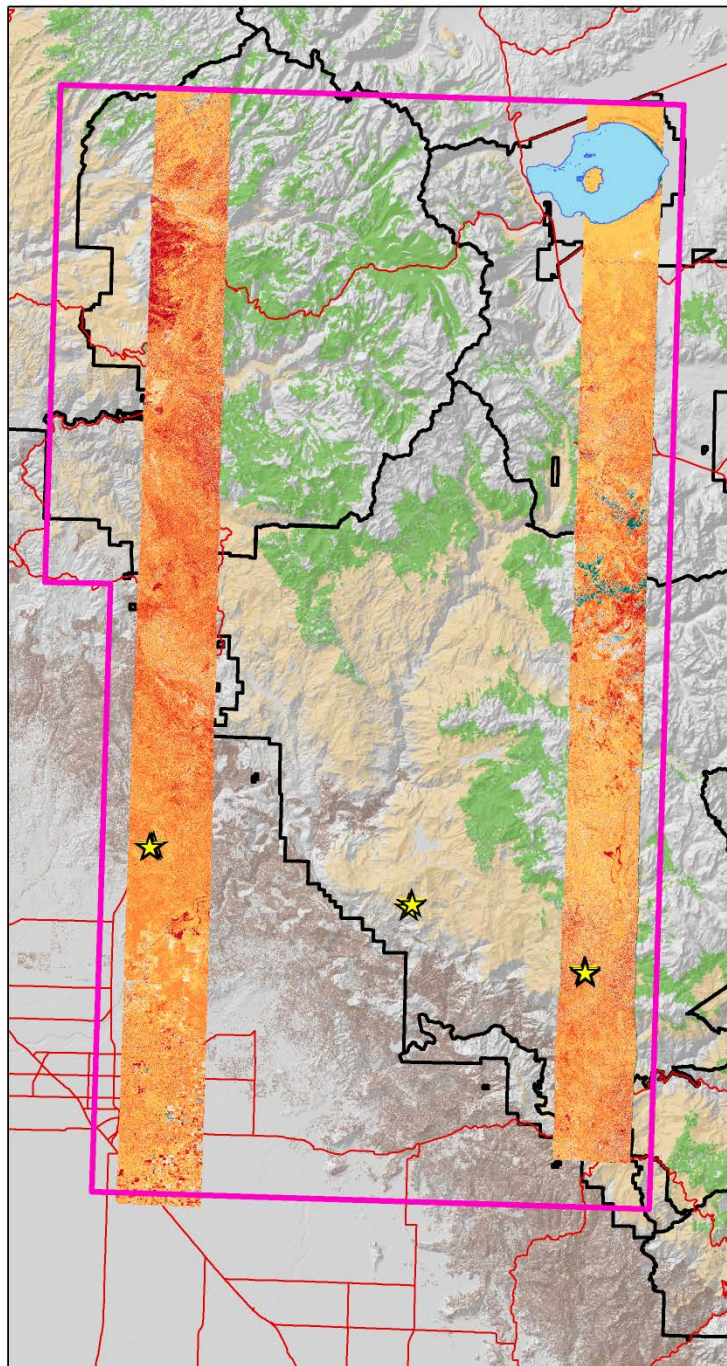
Canopy Water Index



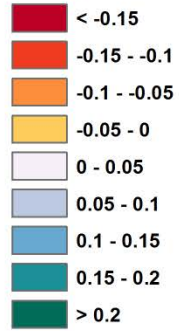
Habitat Band



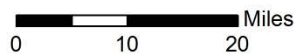
Change in Canopy Water Index: 2013 to 2015



Canopy Water Index Change



Habitat Band



Project Parts

Plot Data

Historical Plot Data

Targeted Project Plot Data

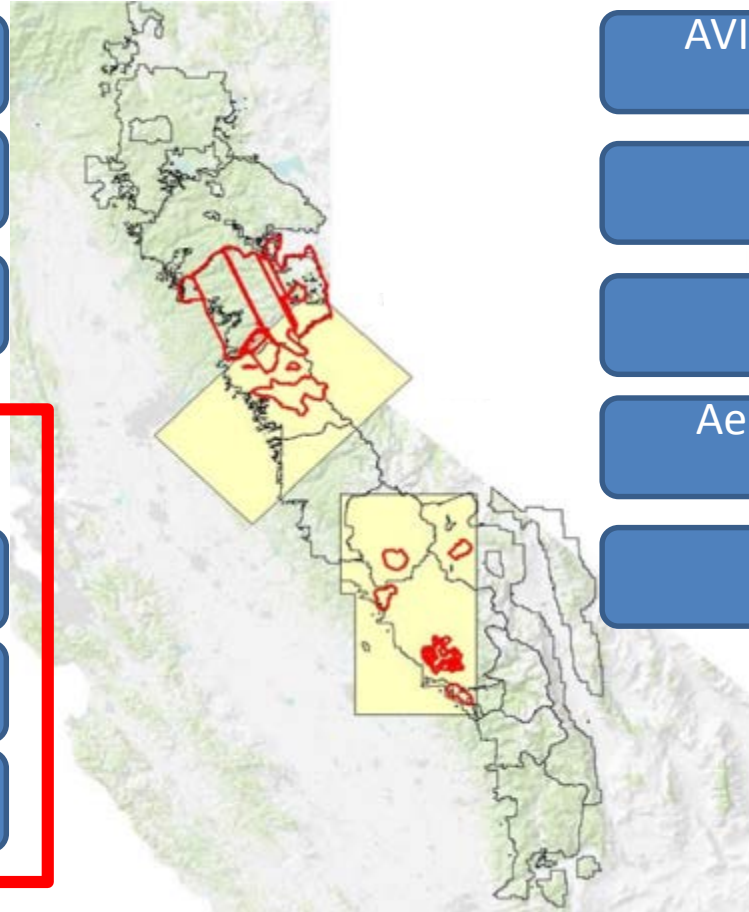
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Leaf Data

Leaf Water Content

Leaf Spectra

Water pressure



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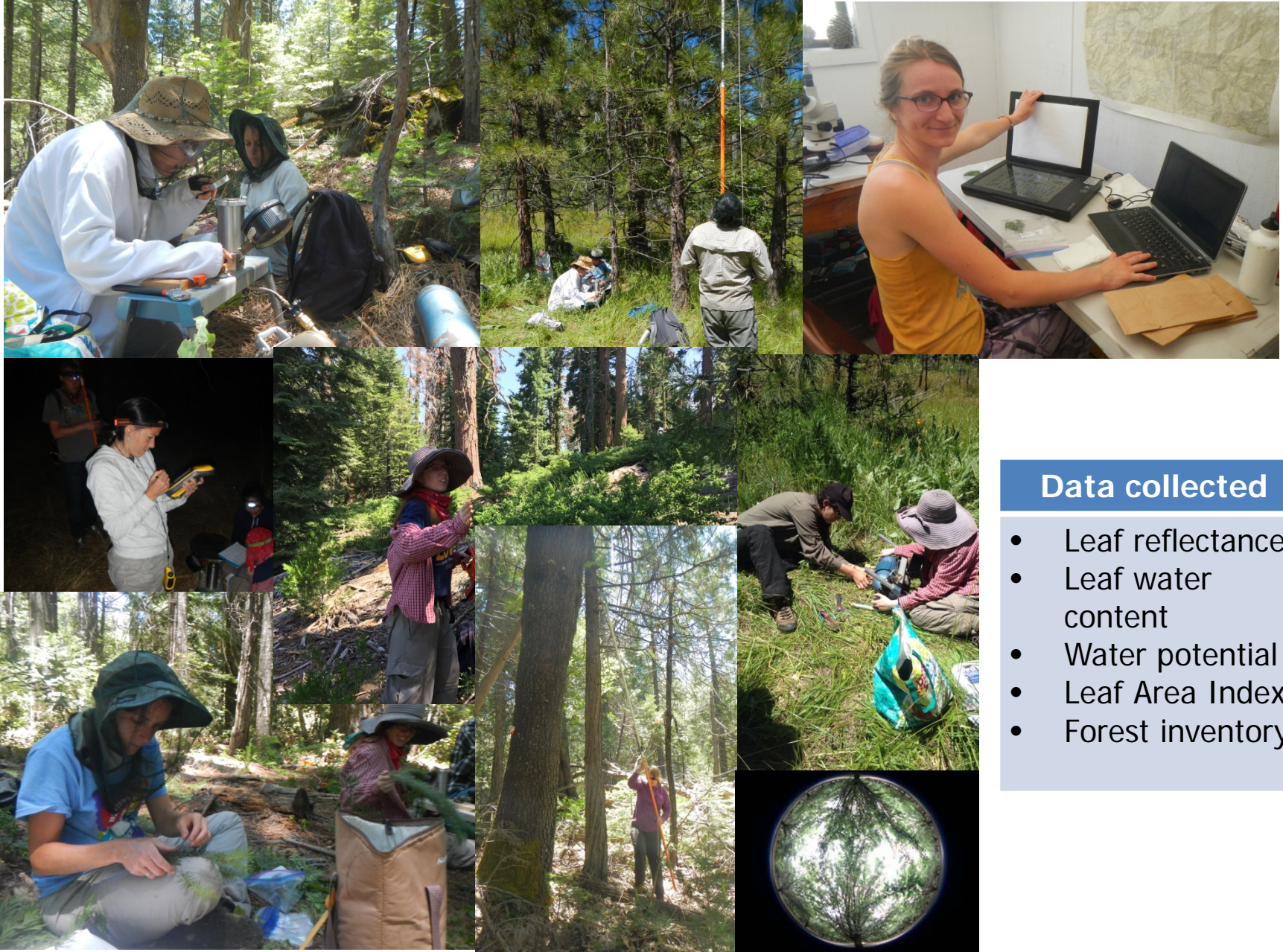
GIS DATA

Stand Treatments – prescribed burn (perimeters), thinning, combination, other

Climate Data & models – PPT, Tmin, Tmax, CWD, Snow, Recharge, Runoff

Environmental Data – topographic roughness, aspect, slope, geology, landcover, etc.

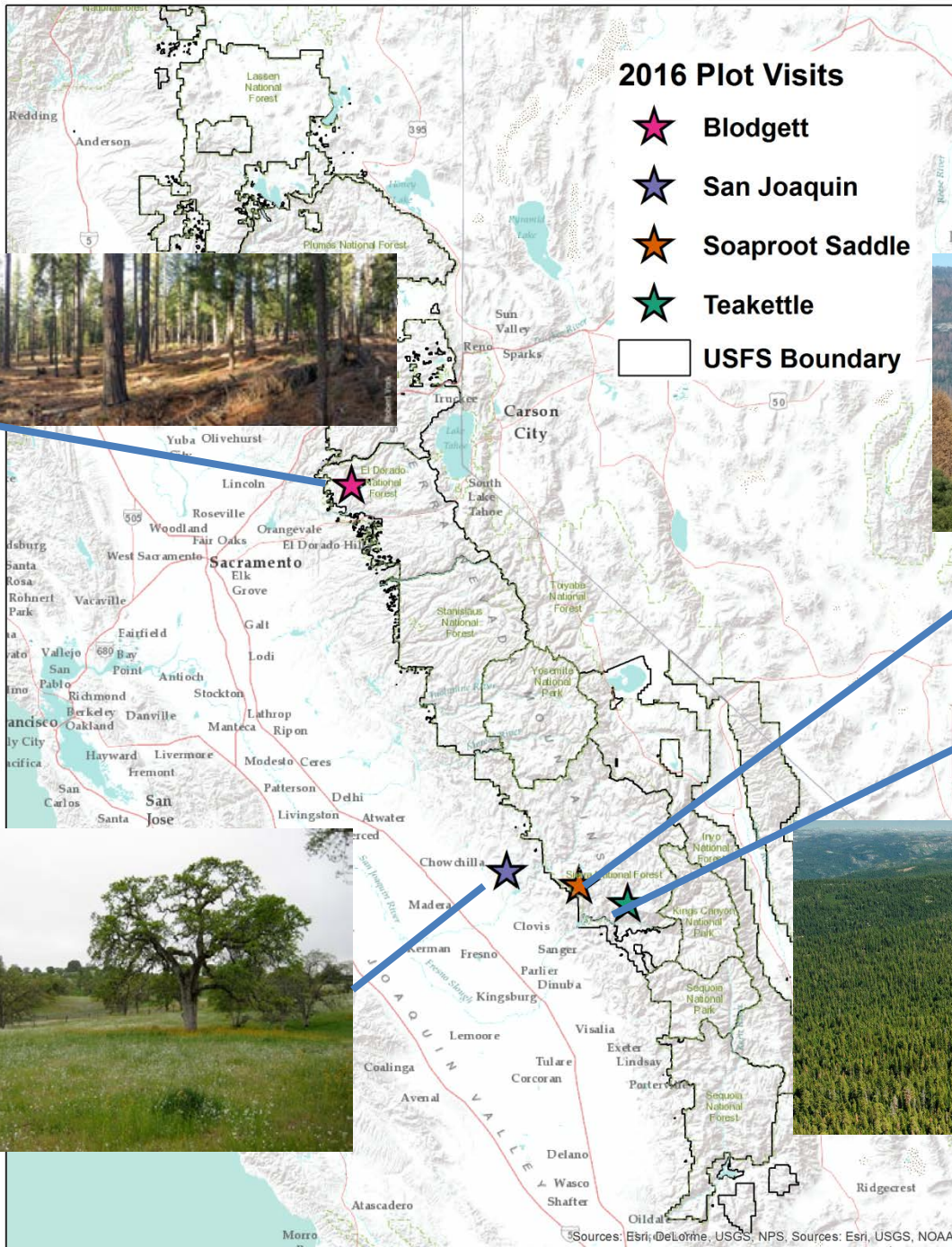
Fieldwork: June 2016



Data collected

- Leaf reflectance
- Leaf water content
- Water potential
- Leaf Area Index
- Forest inventory

Blodgett Forest



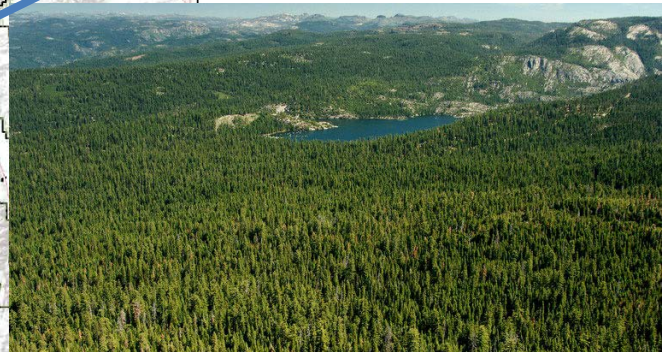
2016 Plot Visits

- ★ Blodgett
- ★ San Joaquin
- ★ Soaproot Saddle
- ★ Teakettle
- USFS Boundary

Soaproot Saddle



Teakettle Experimental Range



San Joaquin Experimental Range



Sources: Esri, DeLorme, USGS, NPS, Sources: Esri, USGS, NOAA

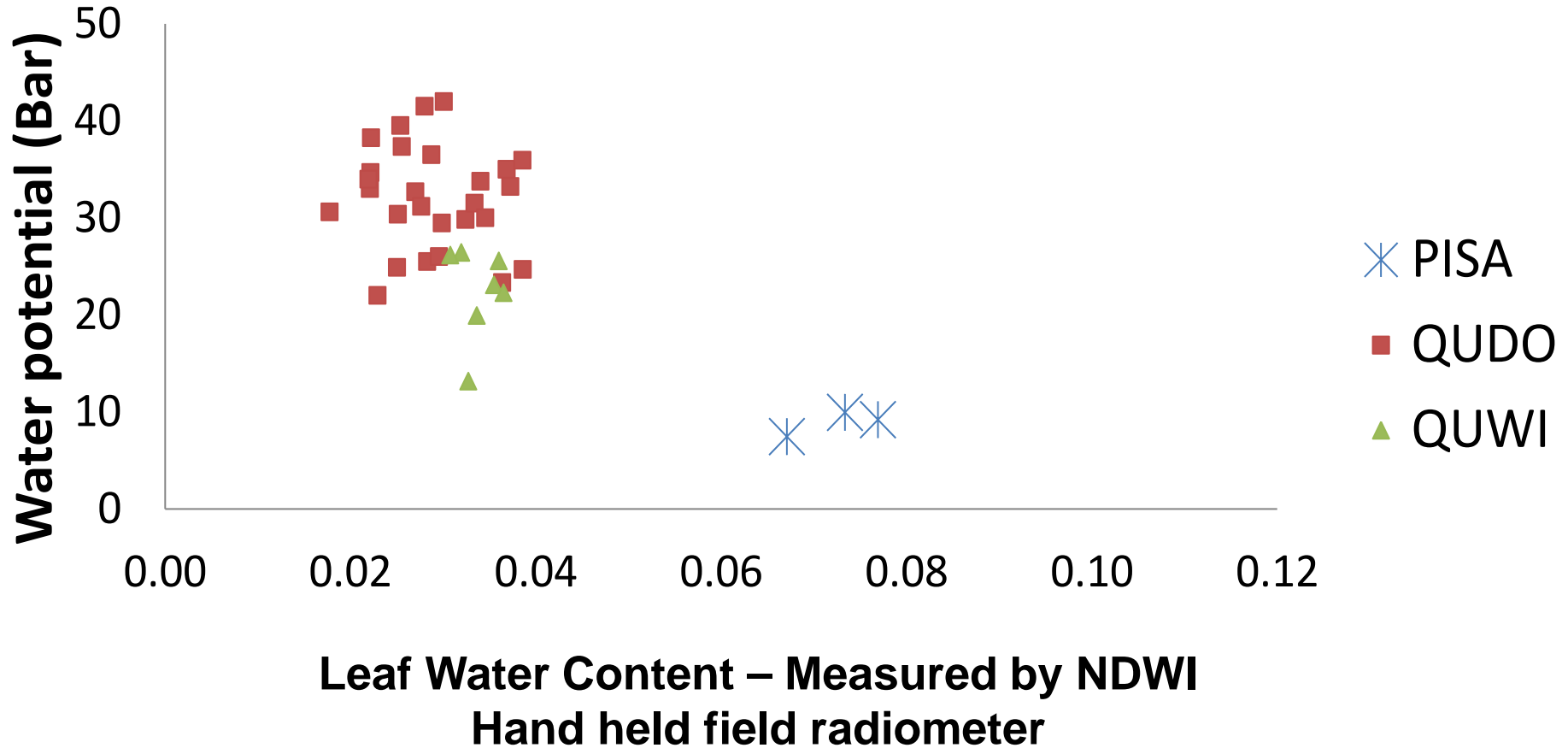
Study Sites	ECOSYSTEM	FOCAL SPECIES
Teakettle Experimental Forest (TEAK)	high elevation conifer forest	<i>Abies concolor</i> , <i>Abies magnifica</i> , <i>Ceanothus cordulatus</i> , <i>Pinus jeffreyi</i>
Blodgett Forest (BLOF)	mixed broadleaf/conifer forest	<i>Quercus kelloggii</i> , <i>Abies concolor</i> , <i>Calocedrus decurrens</i> , <i>Pinus ponderosa</i>
Soaproot Saddle (SOAP)	mixed broadleaf/conifer forest	<i>Quercus kelloggii</i> , <i>Quercus chrysolepis</i> , <i>Pinus ponderosa</i> , <i>Calocedrus decurrens</i> , <i>Arctostaphylos spp.</i>
San Joaquin Experimental Range (SJER)	oak savanna woodland	<i>Quercus douglasii</i> , <i>Quercus wislizeni</i> , <i>Pinus sabiniana</i>

Leaf level	Canopy level
<ul style="list-style-type: none"> • Leaf reflectance • Leaf water content (LWC) • Leaf mass area (LMA) • Leaf thickness • Water potential measurement (pre-dawn and midday) 	<ul style="list-style-type: none"> • Leaf Area Index • Canopy cover or gap fraction • Plot Inventory: tree species, location, height, DBH, canopy base height, canopy width

Data collected

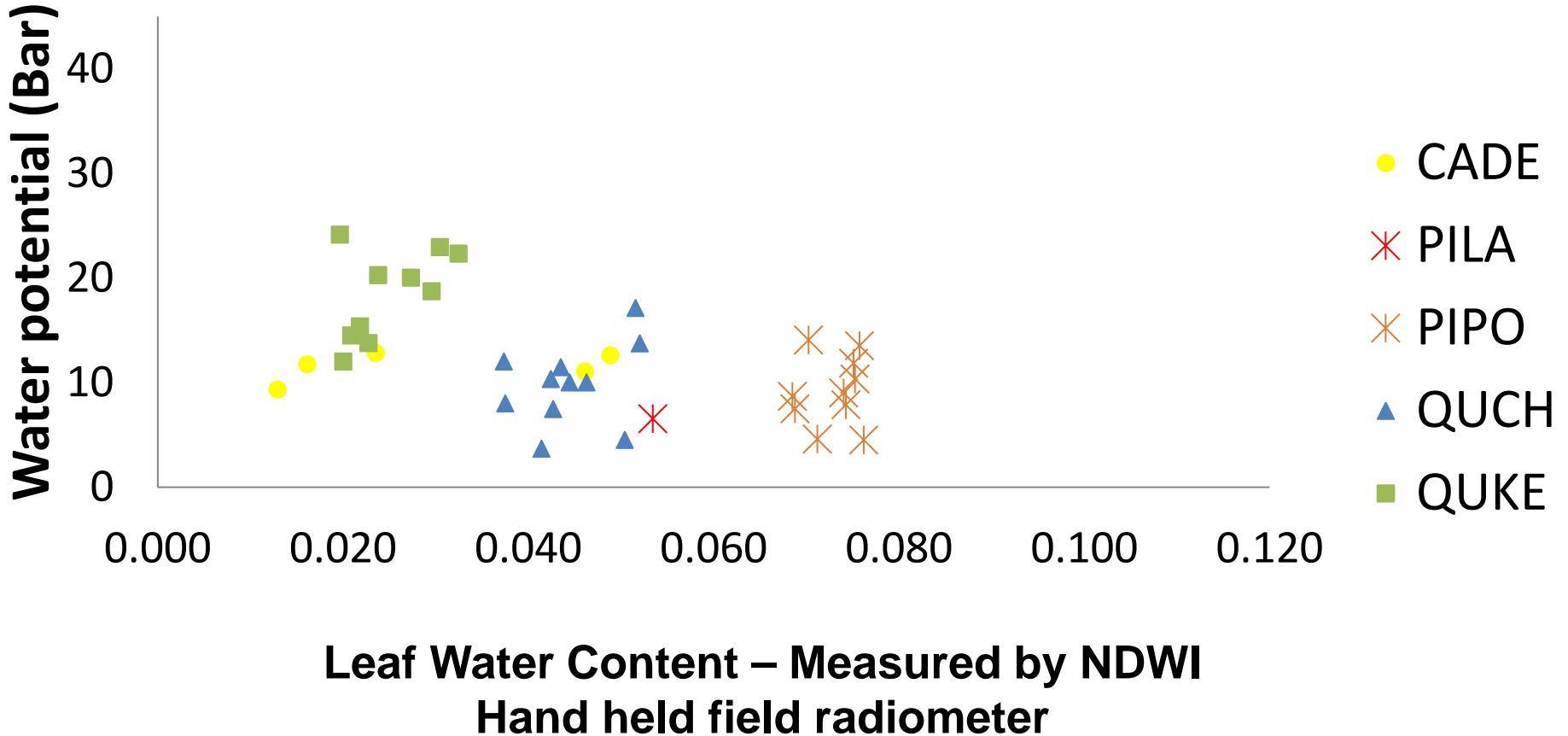
Water pressure vs leaf water spectral indexes

Oak savanna woodland 520 m



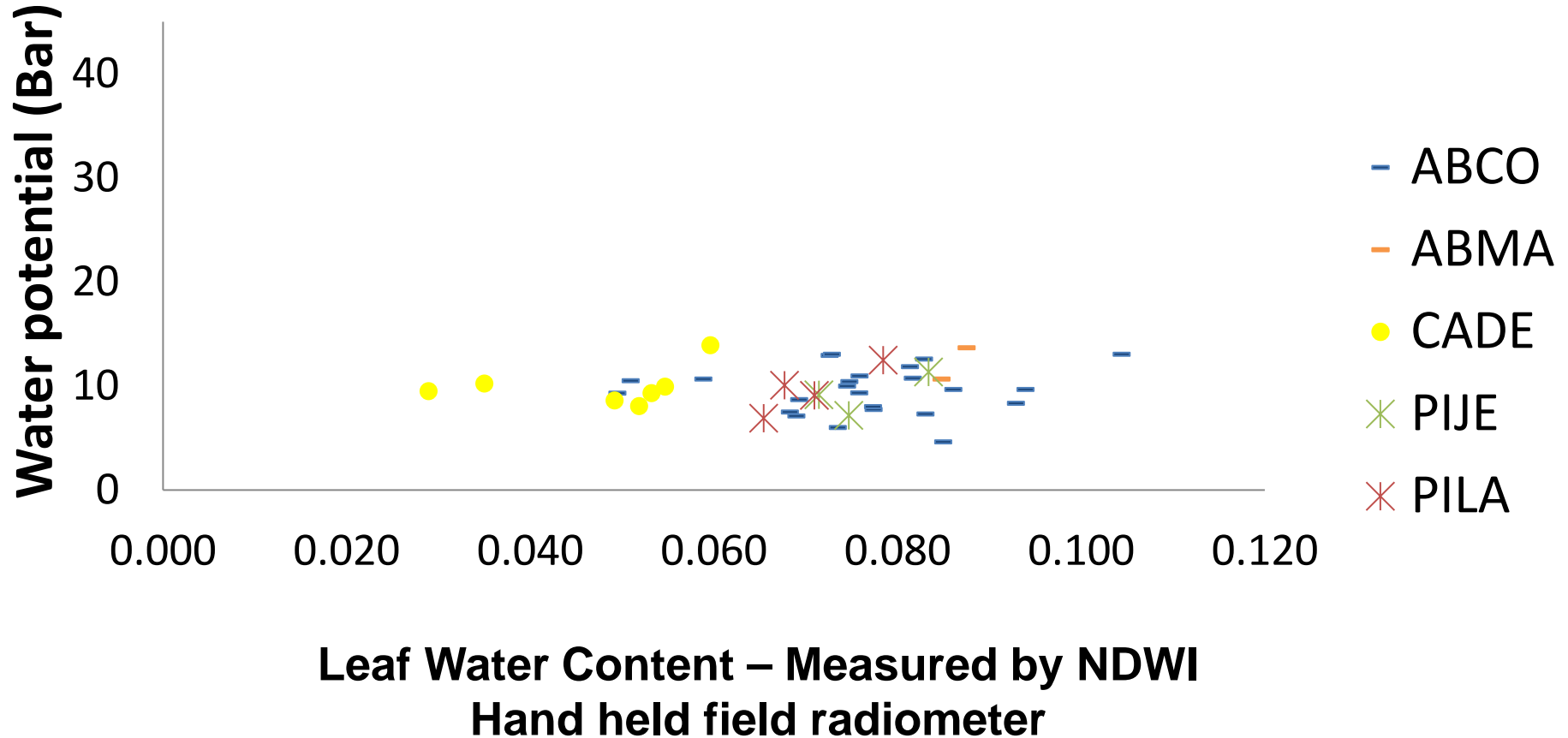
Water pressure vs leaf water spectral indexes

Mixed broadleaf/conifer forest



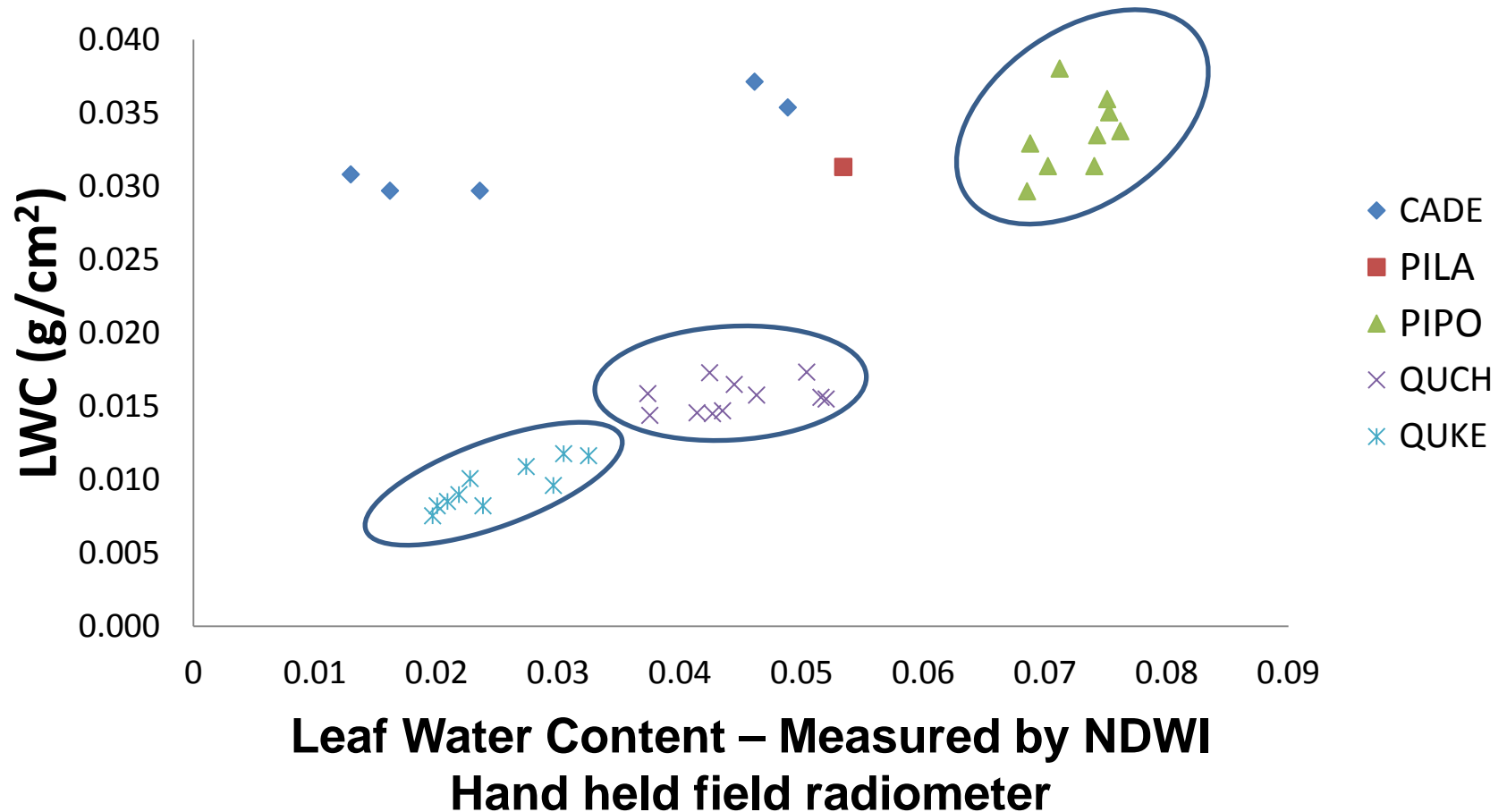
Water pressure vs leaf water spectral indexes

Red Fir – White Fir ~2300m



Leaf water content vs leaf water spectral indexes

LWC vs NDWI



Soaproot Saddle (mid-elevation site) Mixed broadleaf / conifer forest

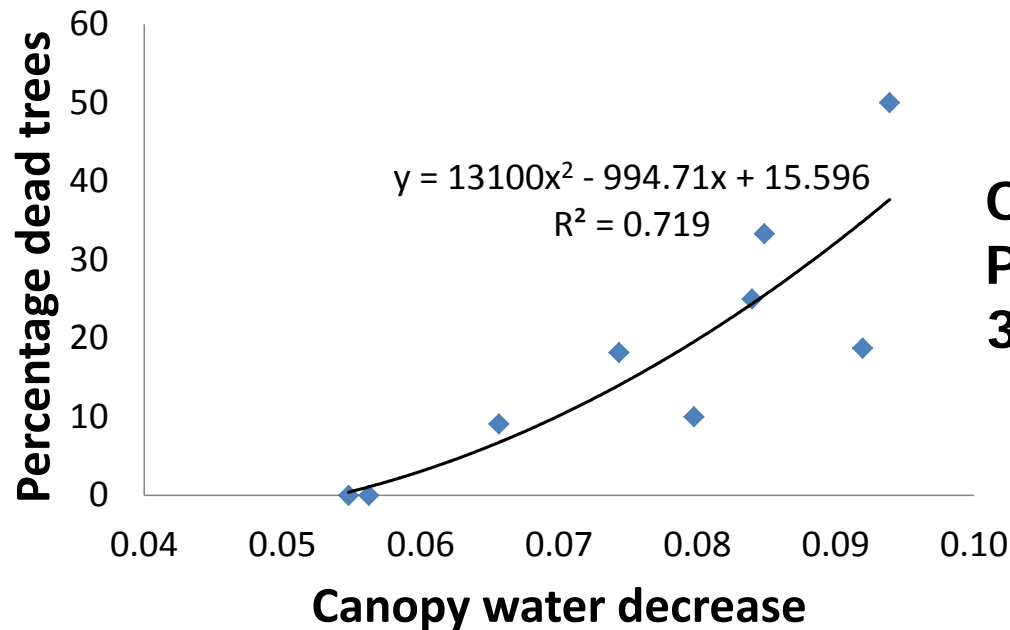
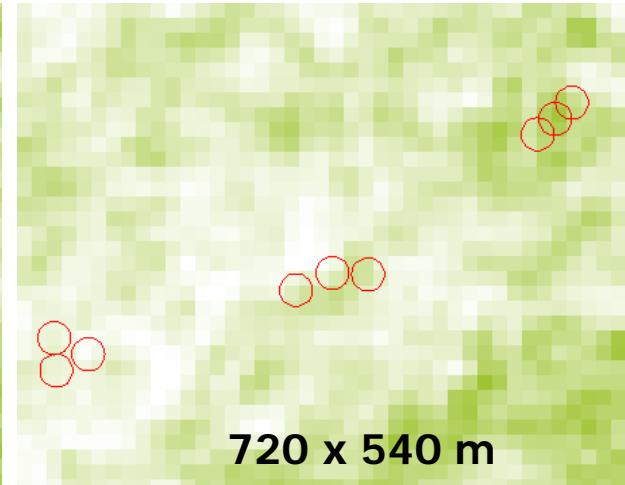
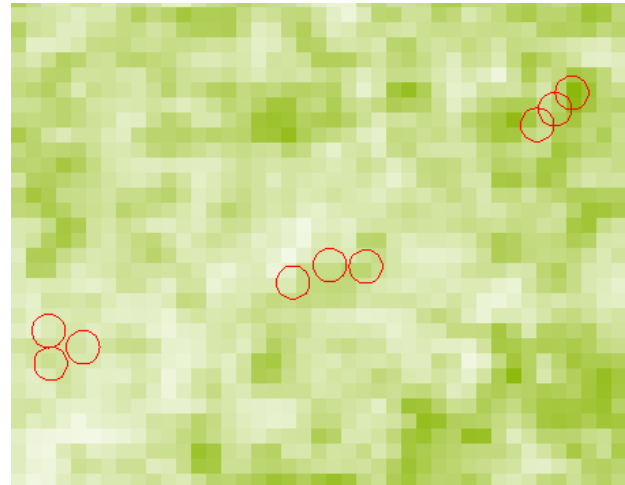
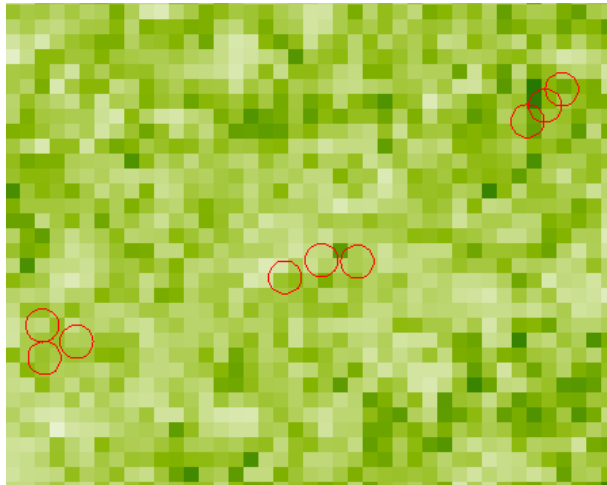
$$\text{LWC} = \frac{\text{Wet Weight (g)} - \text{Dry Weight (g)}}{\text{Leaf area (cm}^2\text{)}}$$

Canopy water decrease vs tree mortality

2013

2014

2015



**Oak Savanna Woodland
Plot Level – Dead Trees Now
3 Years of Imagery**

Canopy water content

High

Low



Project Parts

Plot Data

Historical Plot Data

Targeted Project Plot Data

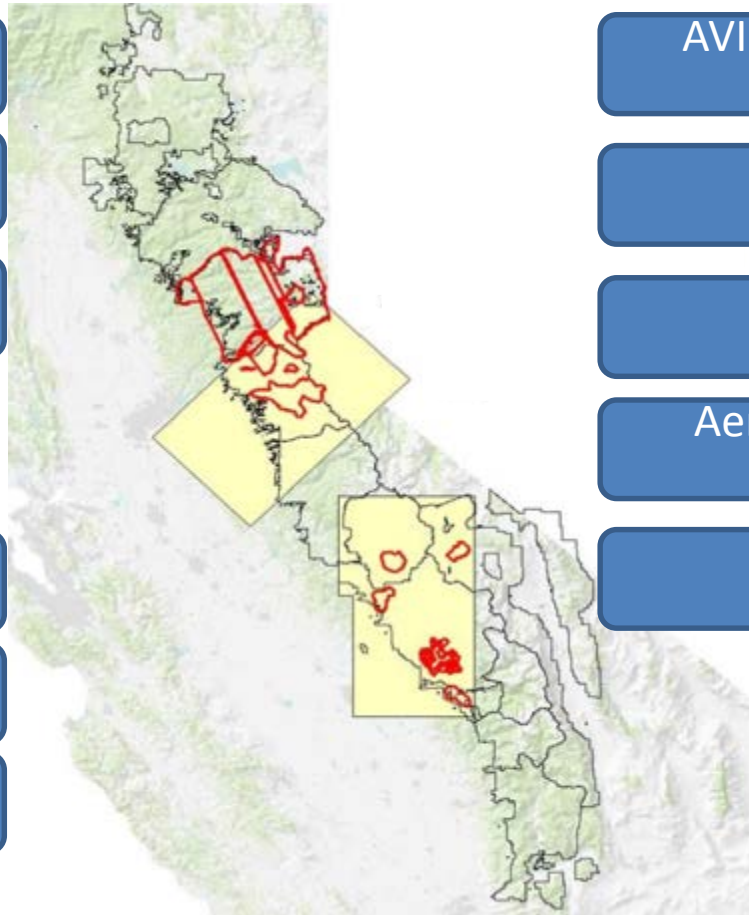
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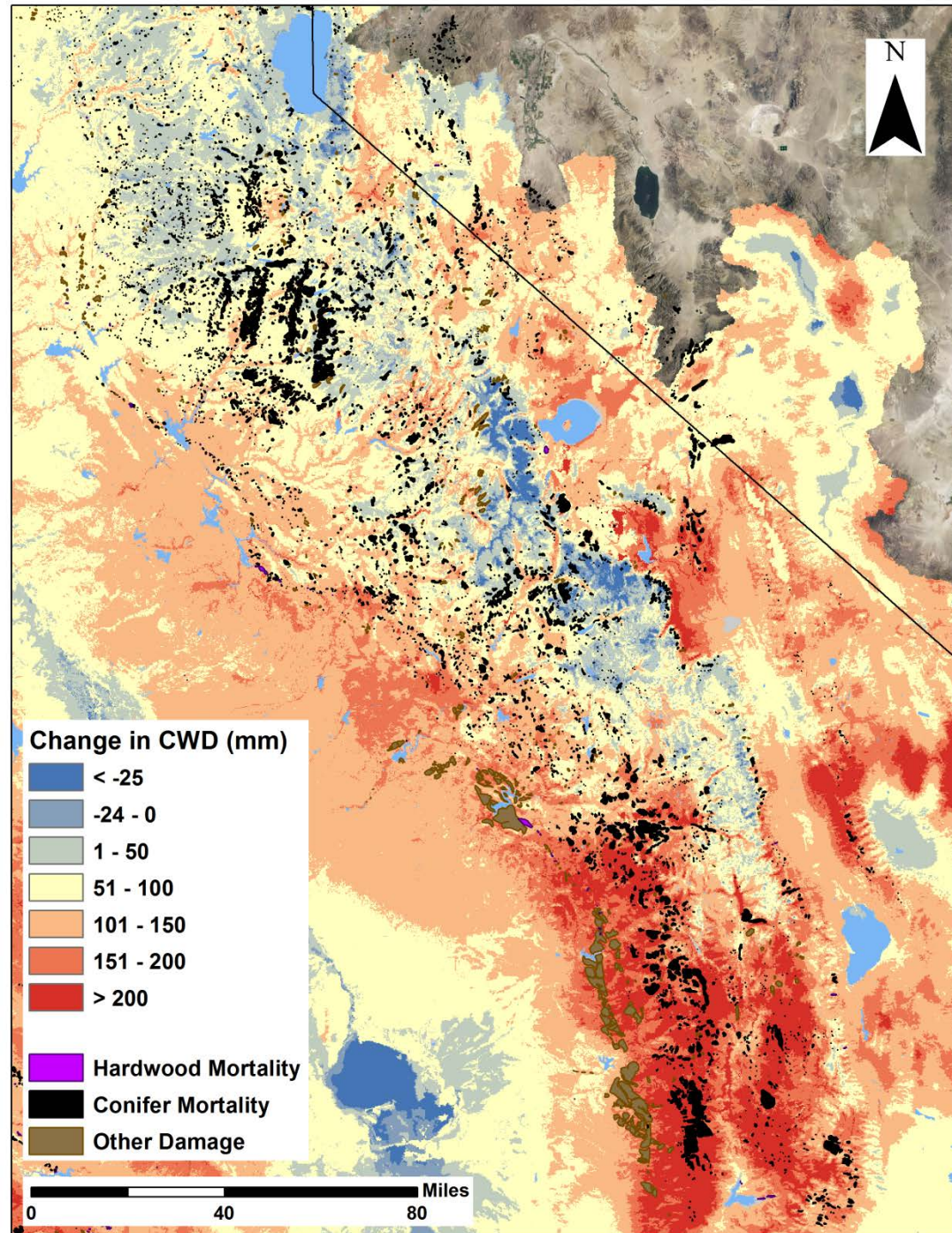
Environmental Data – topographic roughness, aspect, slope, geology, landcover, etc.

**Combining GIS Model outputs
with ongoing drought measures**

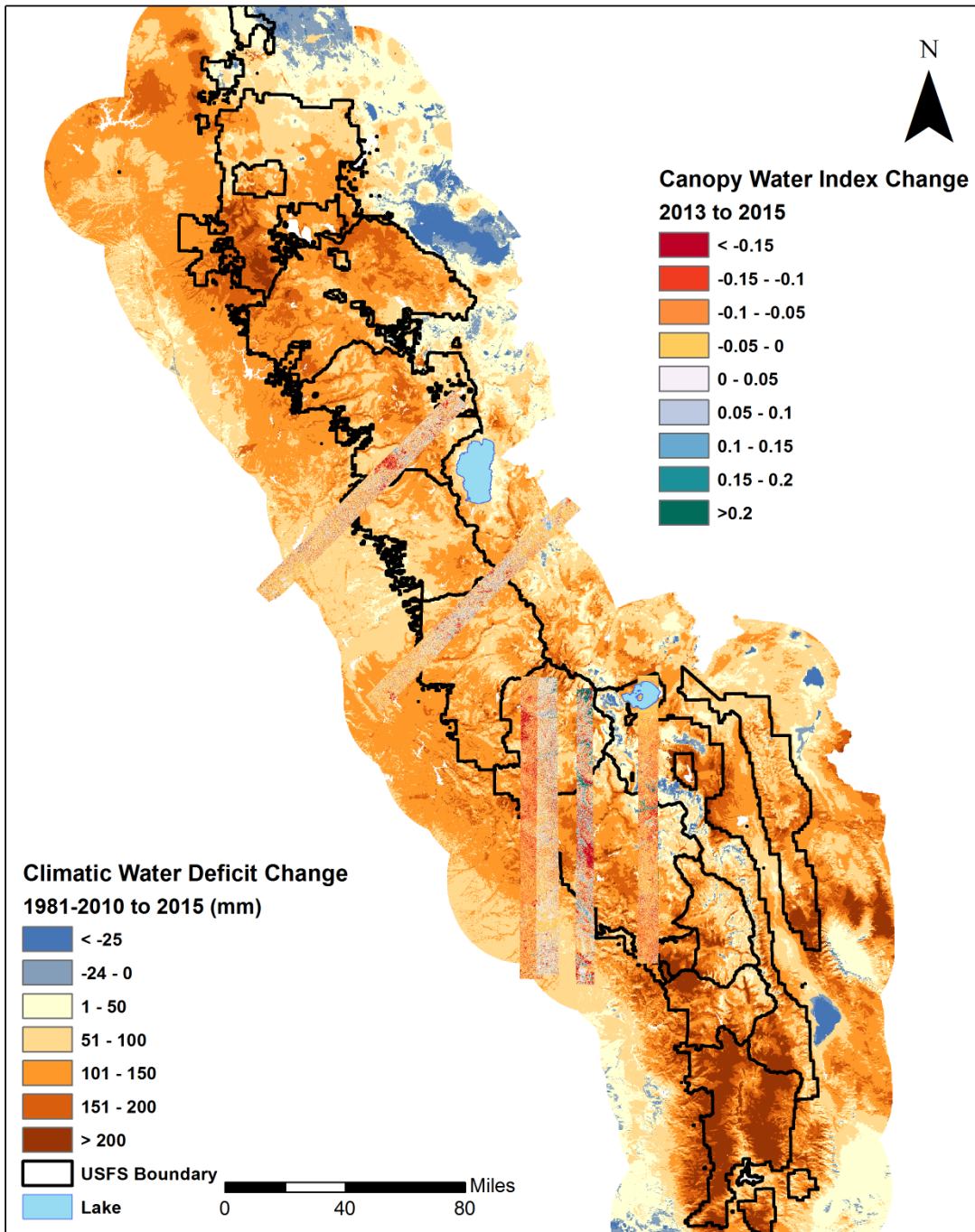
**Change in mean Annual CWD
from 1981-2010 and 2013-2015**

AND

2016 tree mortality state survey



Climatic Water Deficit Change With Canopy Water Index Change



Forest Plots

Water Potential

Remote Sensing @ experimental sites

Remote Sensing using “landscape samples”

Remote Sensing at landscape levels

GIS Integrations

Fire Suppression

No Treatment

Prescribed Burns

Mechanical Thinning

Other?

What Trend Information is critical?

What current condition information is important?

What future projections are needed?

Experimental Treatments at what scale?

What monitoring ratchets forward our understanding?



**Thank you for
your attention**

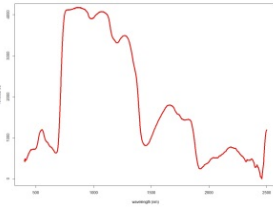
jhthorne@ucdavis.edu

pvanmantgem@usgs.gov





VS

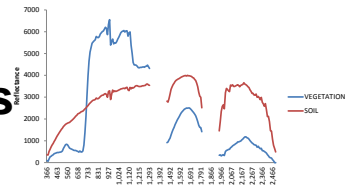


LEAF WATER CONTENT relationship

Direct field leaf water measurements versus leaf water spectral indexes measured with a radiometer



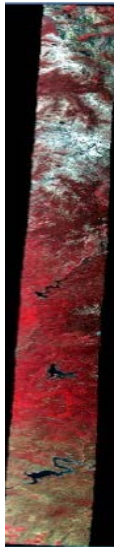
VS



CANOPY WATER CONTENT relationship

Direct field measurements of leaf water content and vegetation structure versus canopy spectral indexes from image spectra

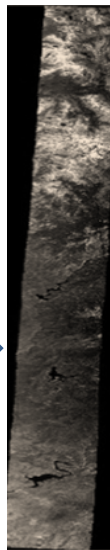
CANOPY WATER CONTENT AT LANDSCAPE



Extrapolation of the canopy water content relationship to the whole image

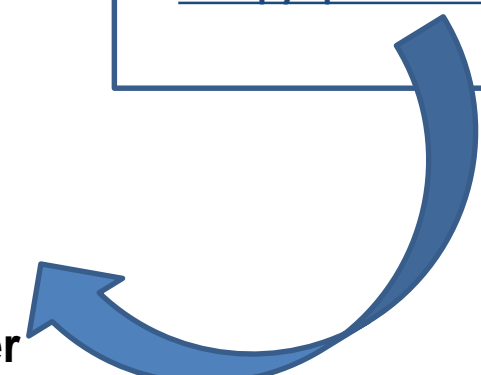


Canopy water content relationship

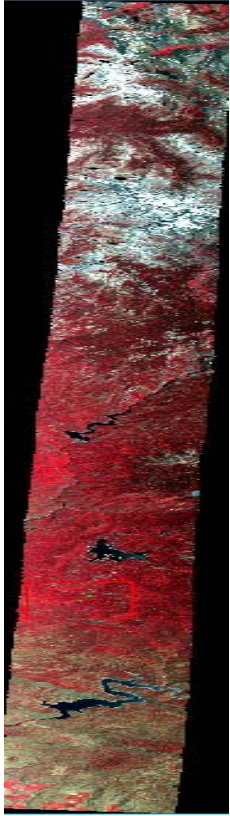


Reflectance

Canopy water



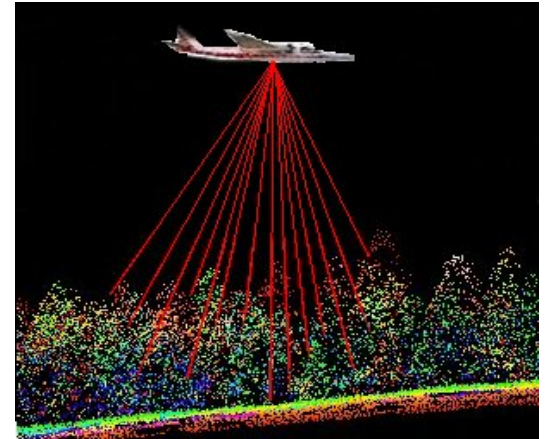
Remote Sensing Data



AVIRIS

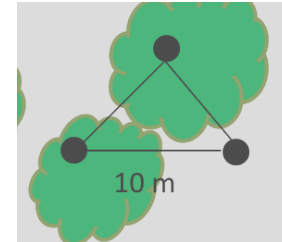
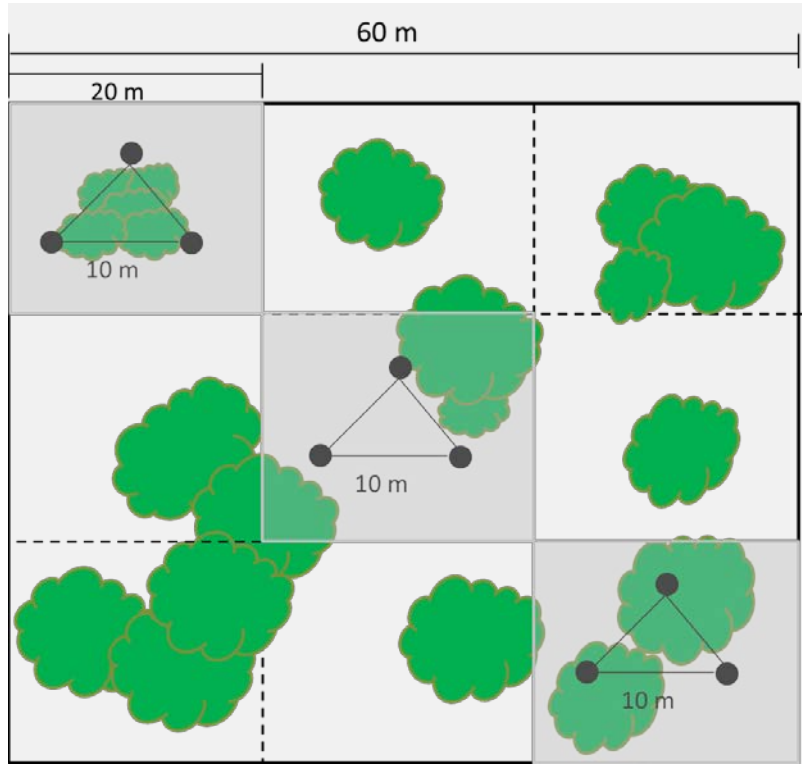
- Airborne LiDAR from NEON Airborne Observation Platform (AOP)
- Imaging spectroscopy data acquired by the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS)

Acquisition date : June 2013



LiDAR

How the data was collected



LAI points

Three plots of 60m each were selected in SJER, SOAP and BLOF and 4 in TEAK

It was selected 3 subplot within each plot (9 subplots per study area- 12 in TEAK)

An inventory plot of 20m radius is defined within each subplot

The 4 dominant trees within the inventory plot were selected to measure the leaf spectral, leaf water content and water pressure.

Three LAI hemispherical photos are taken within each subplot