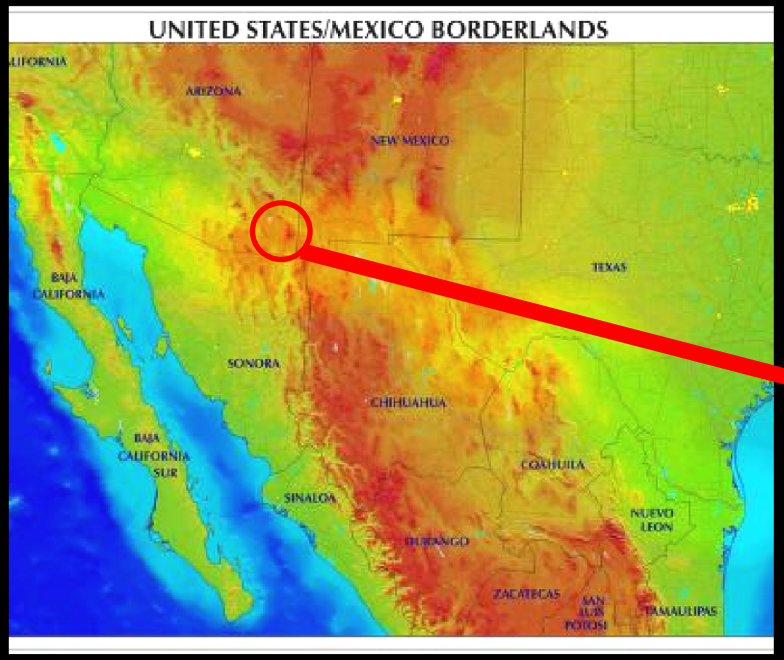
Using ECOSTRESS to Predict Wildfire Effects on Plant Water Relations and Vegetation Structure in an Arizona Pine-oak Forest

Helen Poulos[1] and Andrew Barton[2]

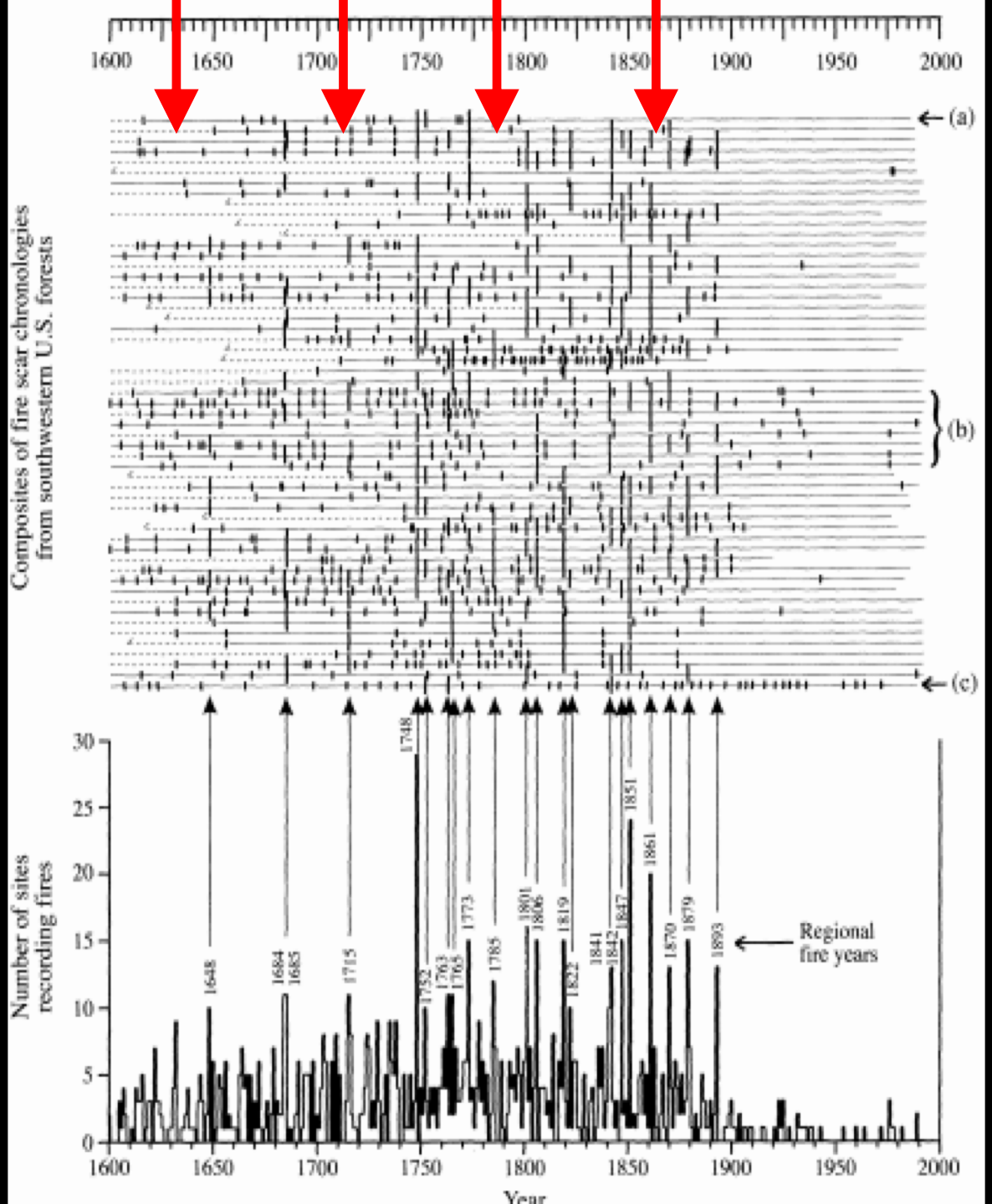
[1]Wesleyan University [2]University of Maine at Farmington

Sky Island Vegetation



Southwest Frequent-fire Regime

- Lightning
- Low-severity, surface
- Every 5-15 yrs
- Regionally synchronized
- Maintained open canopy and diversity



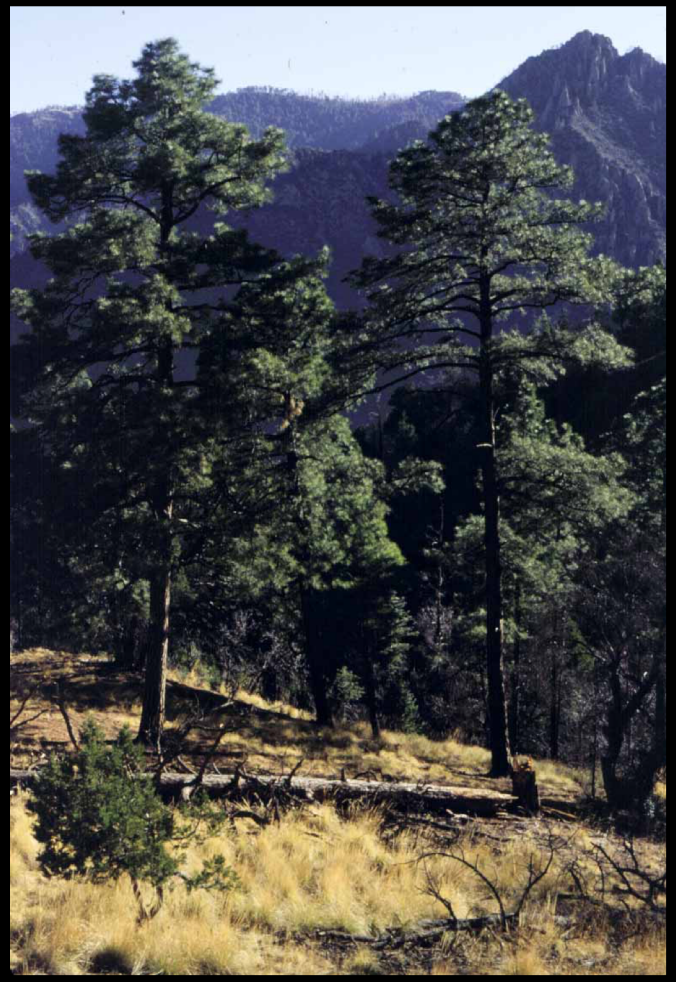
Swetnam et al 1999

Pines

fire resistant

survive fire

fire scar



Oaks

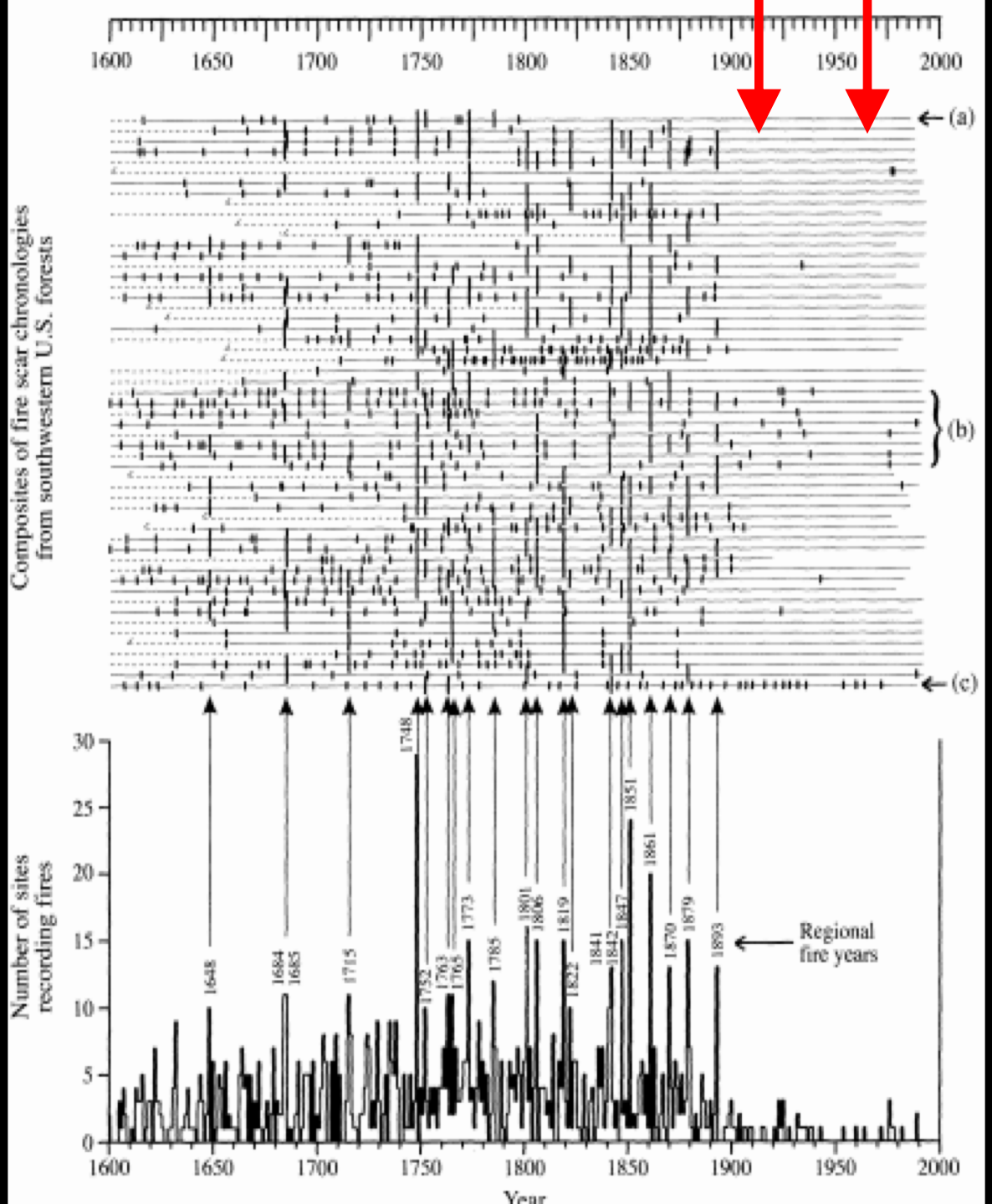
fire resilient

readily top-killed

sprouting

1880-1990
Few Fires

- Livestock grazing
- Fire suppression
- Increased tree density
- Increased dead fuel



Swetnam et al 1999

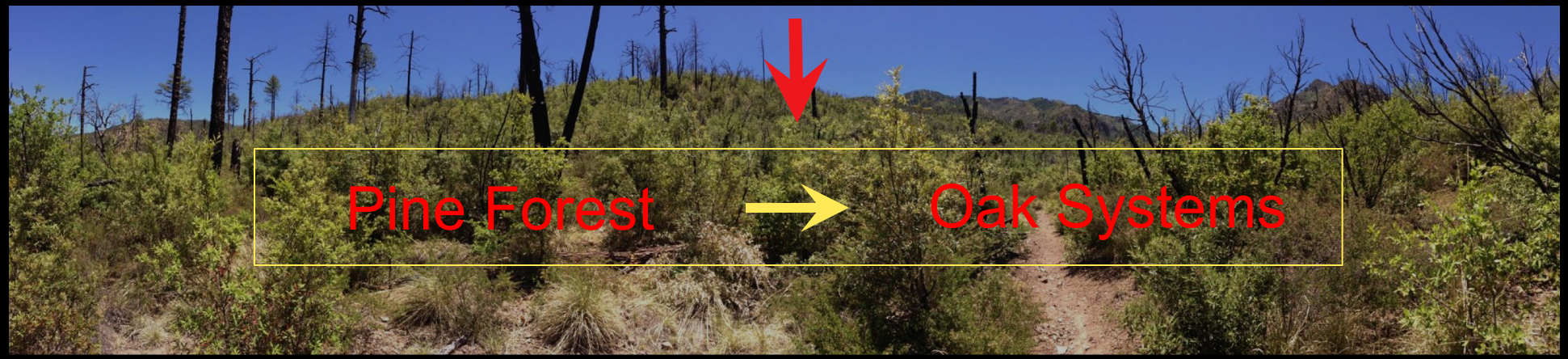
Fire Exclusion

High
Fuel Loads

Climate Change

Increased
Aridity

Large Crown Fires



"…the fear that uncharacteristic fires may convert large areas of pine forest to other vegetation such as oak brush" (Wolfson & Thode 2014).

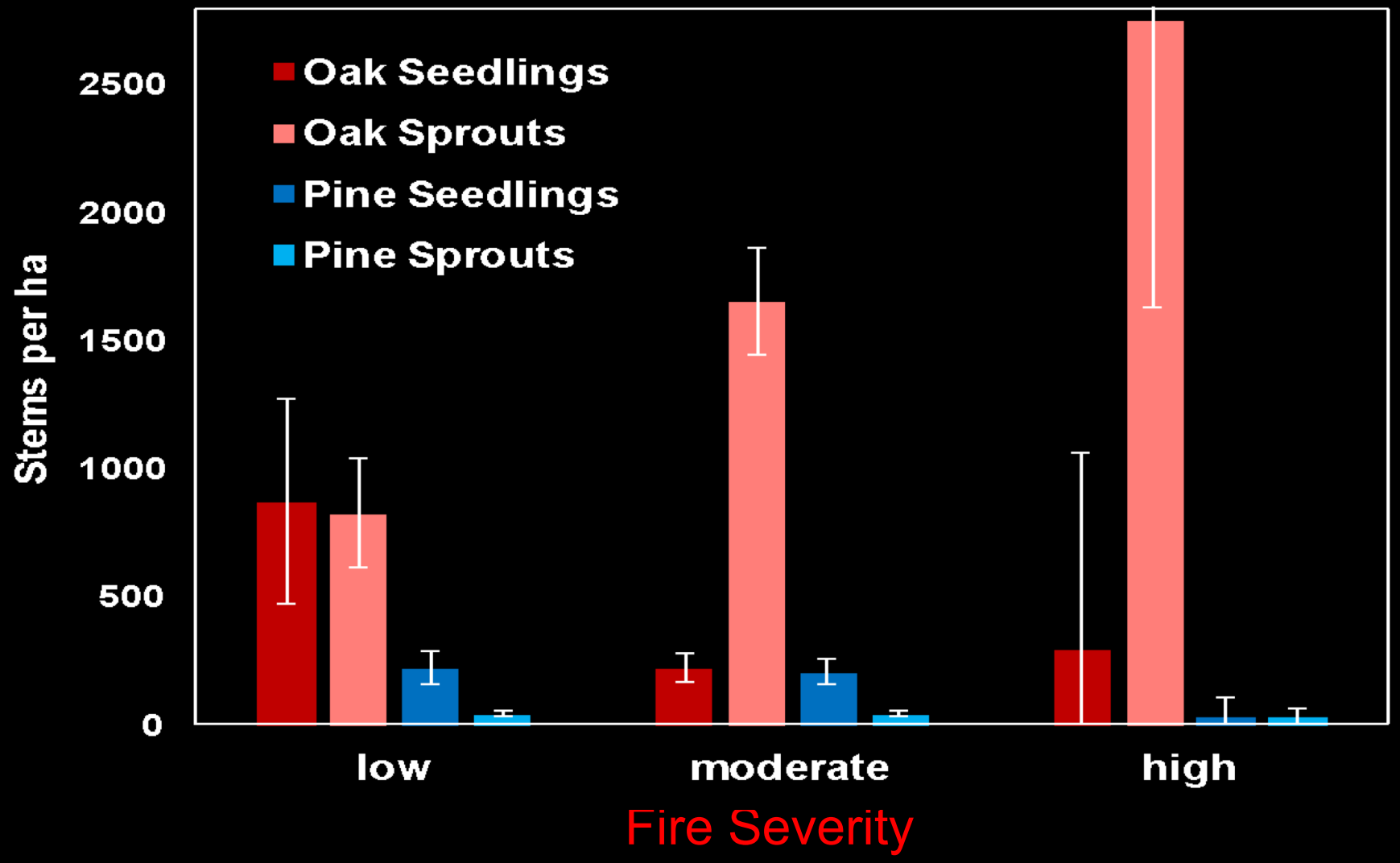
Horseshoe 2 Fire, Chiricahua Mountains 15 May 2011
~225,000 acres

Earth Observatory, NASA

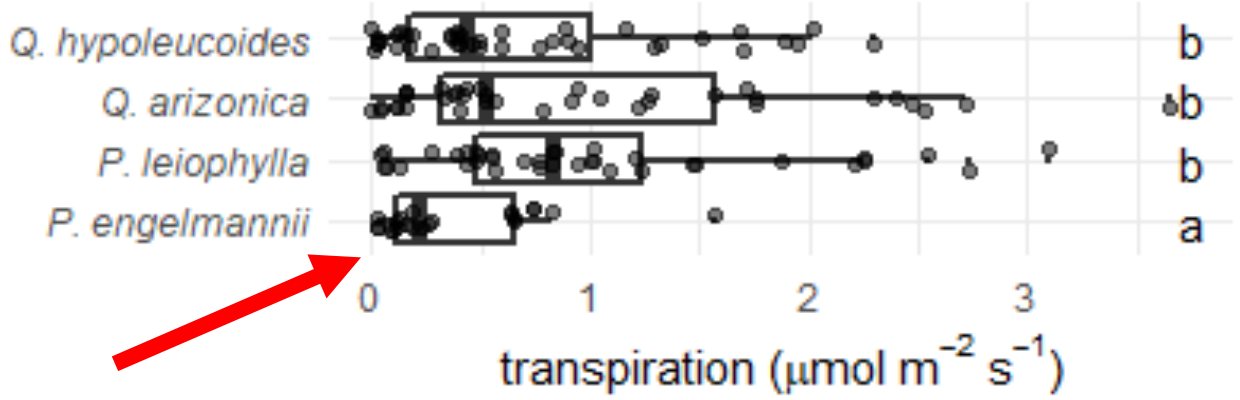
Geoff Bender, SWRS

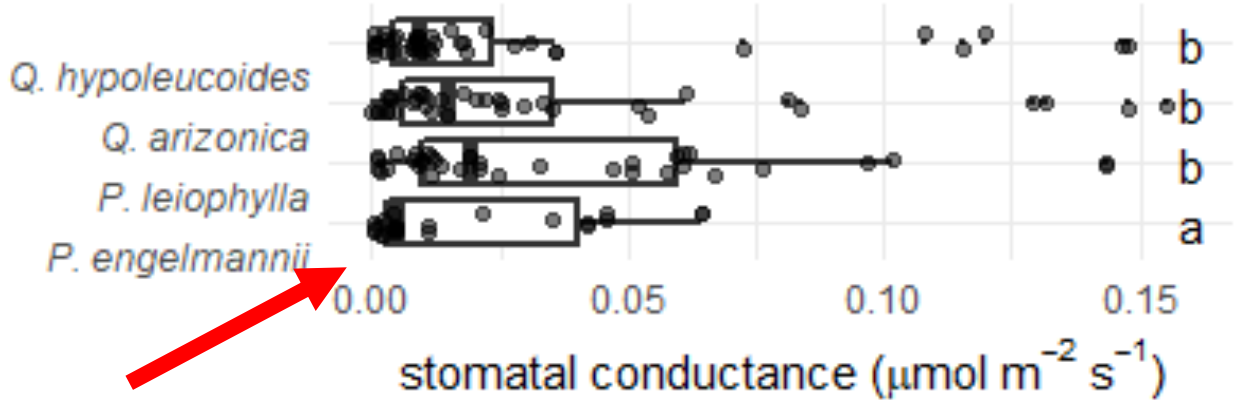

Madrean Pine-Oak Forest
?

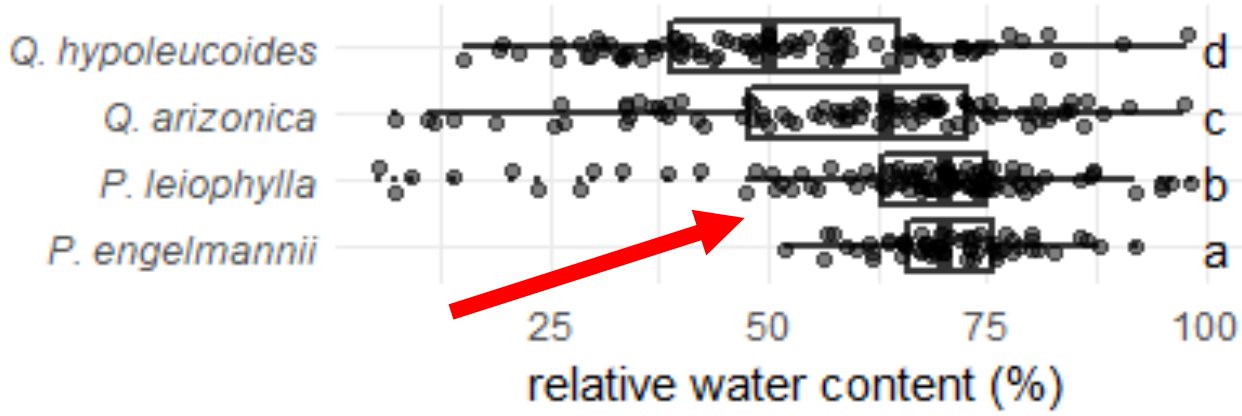
Severe Fire → Oak Sprouts

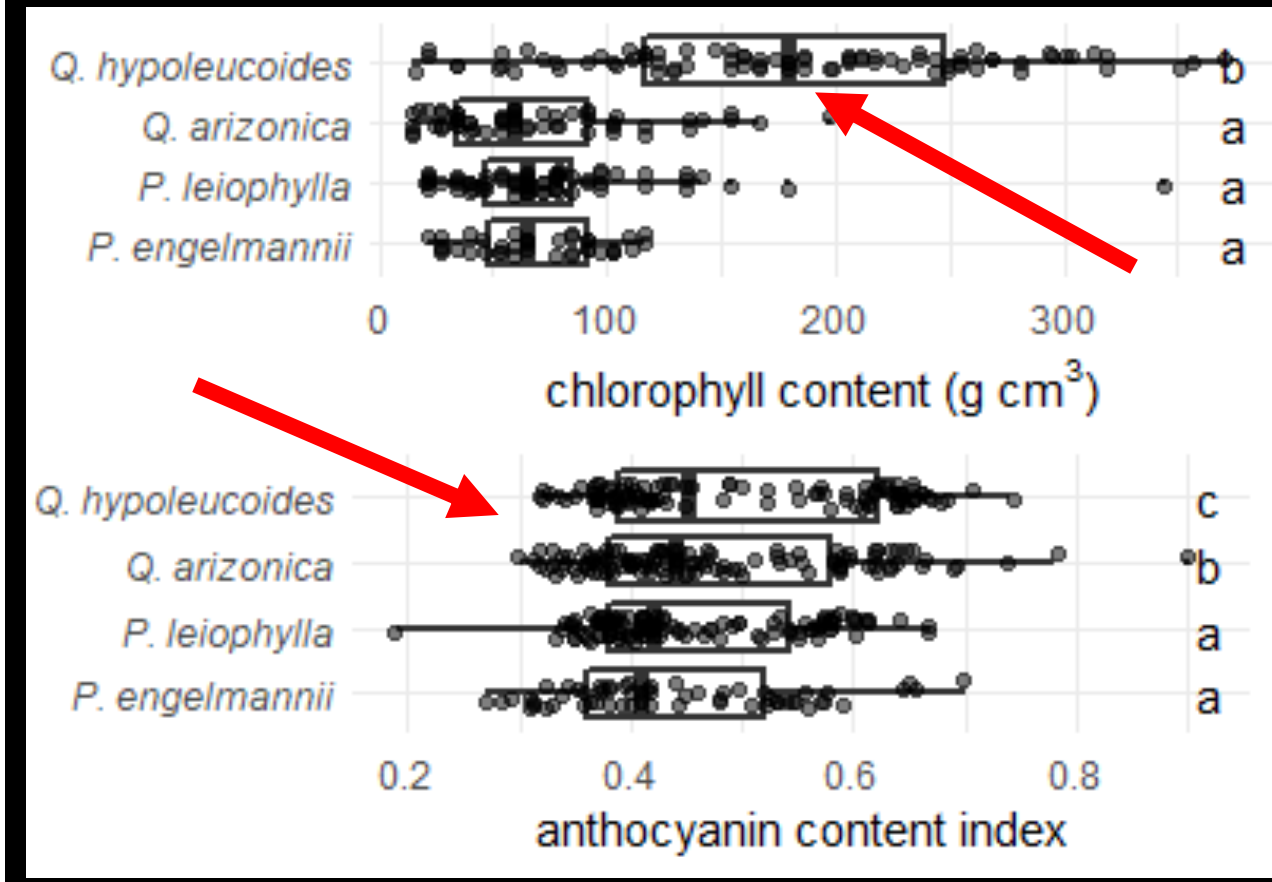


Barton and Poulos 2018, Forest Ecology and Management









Pines: isohydric, low photo capacity
Oaks: anisohydric, high photo capacity

Poulos et al. 2019 Forest Ecology and Managemnt

Fire Resistant
Post-fire Seeder
Isohydric

Fire Resistant
Weak Post-fire Sprouter
Isohydric

Fire Resilient
Vigorous Post-fire Sprouter
Anisohydric

low → high

Competitive advantage in the arid, high-severity wildfire landscape

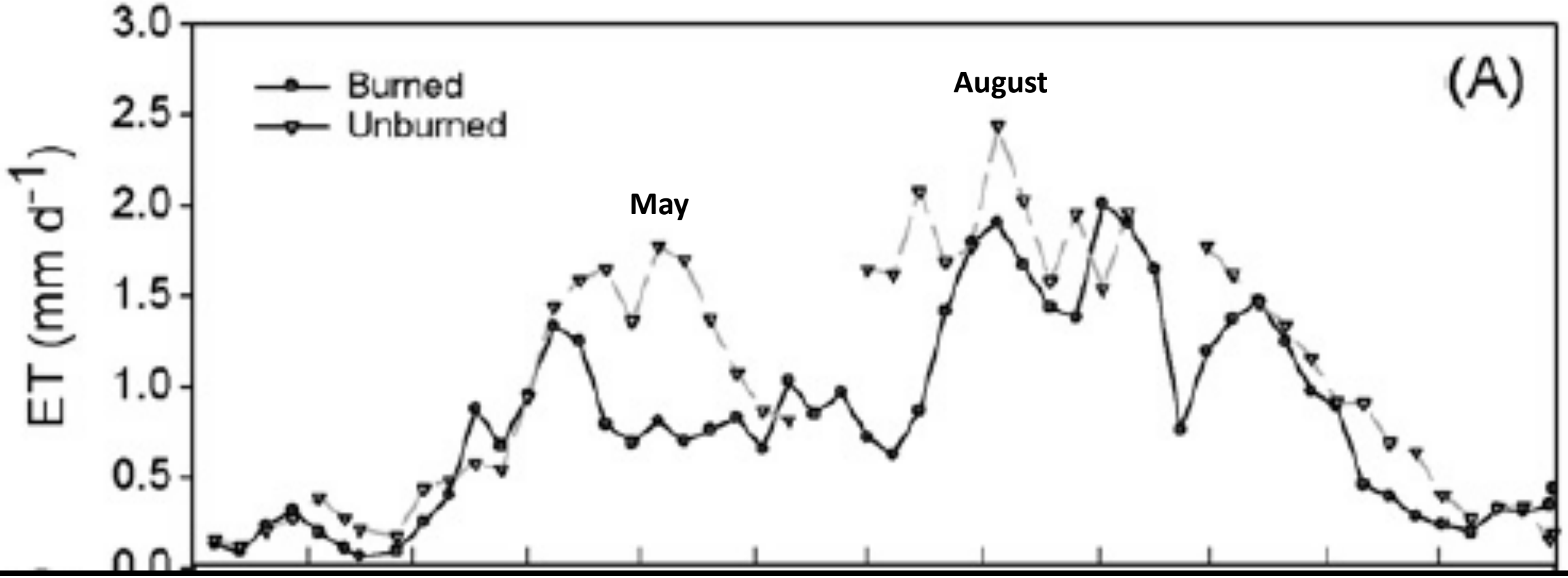
Study Objectives

1. Examine how fire severity influences post-fire field ET and ECOSTRESS ET and ESI

2. Validate ECOSTRESS ET and ESI with field sapflow and psychrometer measurements

3. Compare ECOSTRESS ET performance with MODIS-derived products

4. Examine how fire severity and post-fire vegetation structure drive ET and ESI



Weekly evapotranspiration (ET) in a burned versus unburned stand, calculated via eddy covariance at a northern Arizona wildfire site. Taken from Ha et al. (2015).

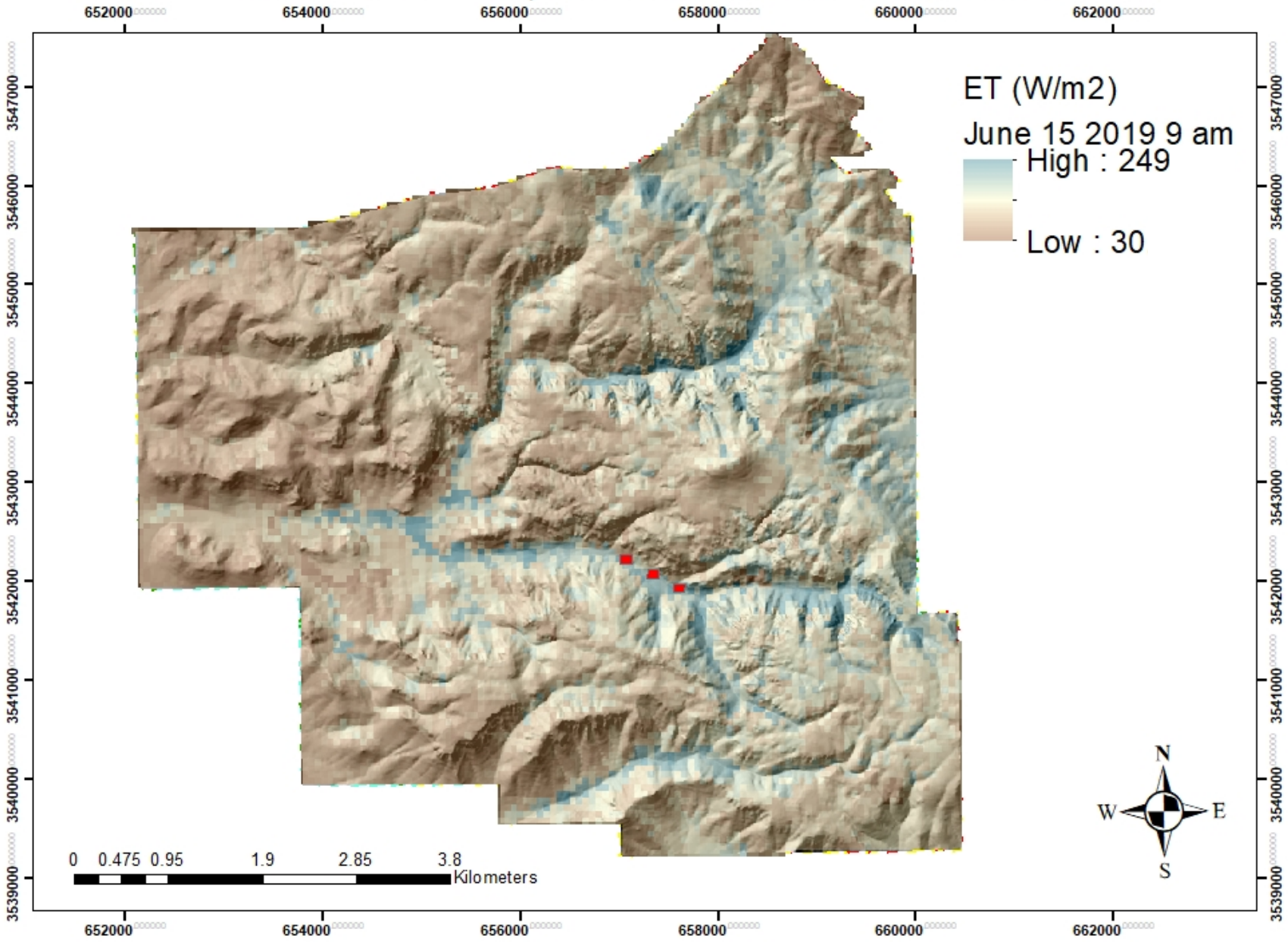
1. Relate field ET and ECOSTRESS ET and ESI to fire severity

low-severity

moderate-severity

high-severity

ET June 15, 2019 9 am local time



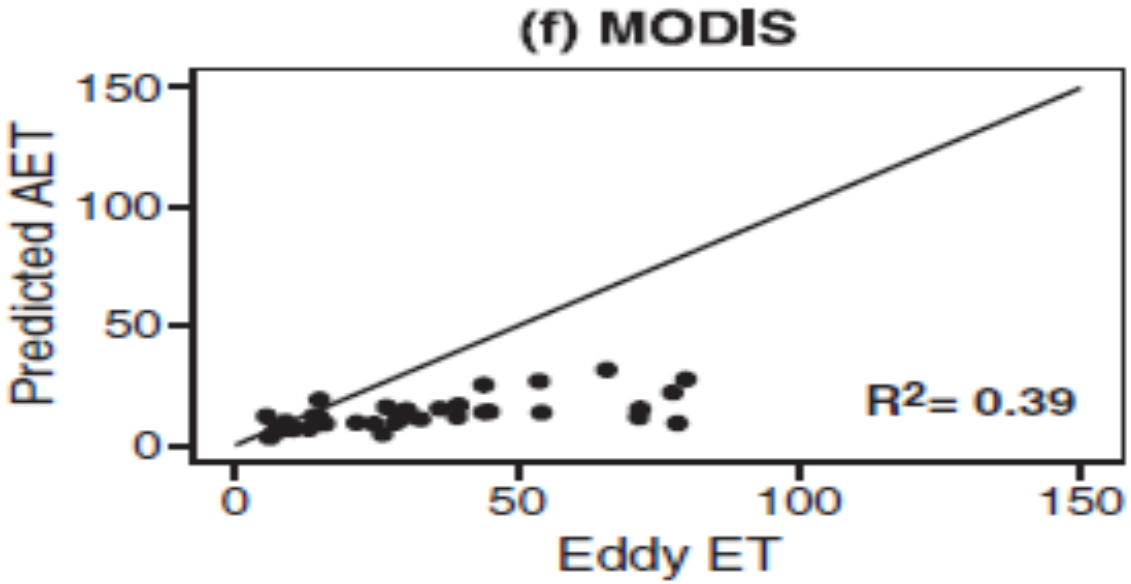
dNBR: Miller and Thode 2007 Rem Sens Env

2. Validate ECOSTRESS ET and ESI with field measurements

In June 2020 Install…

- 20 sapflow sensors in each fire severity block (low, mod, high) in pine-oak forest
- 1 weather station in each block - Bowen Ratio calculations
- Additional psychrometers on oaks in each site

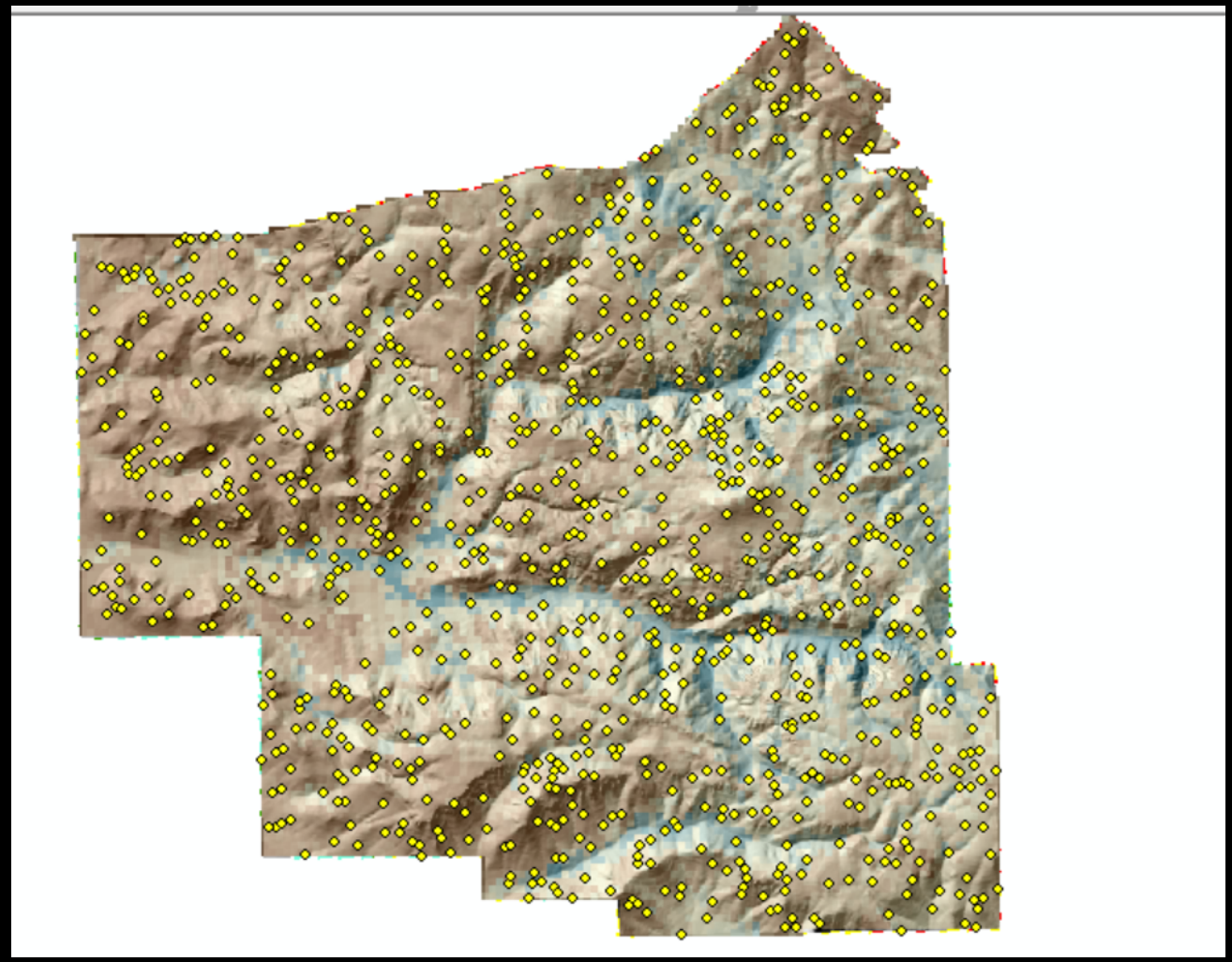
3. Compare ECOSTRESS ET with MODIS-derived products

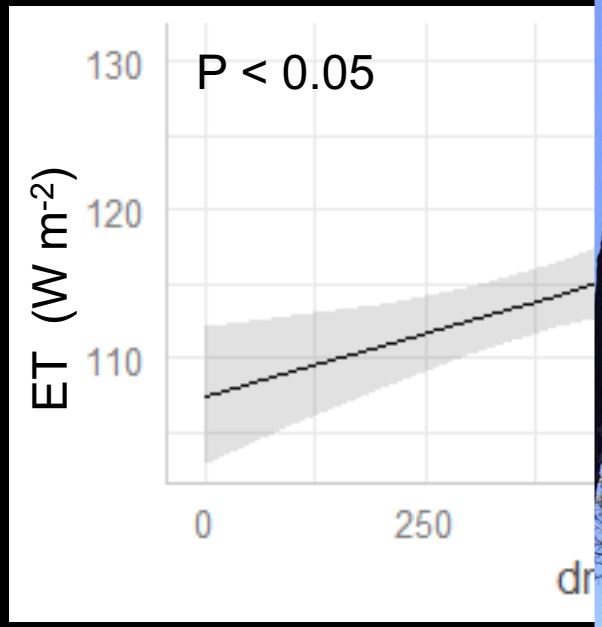


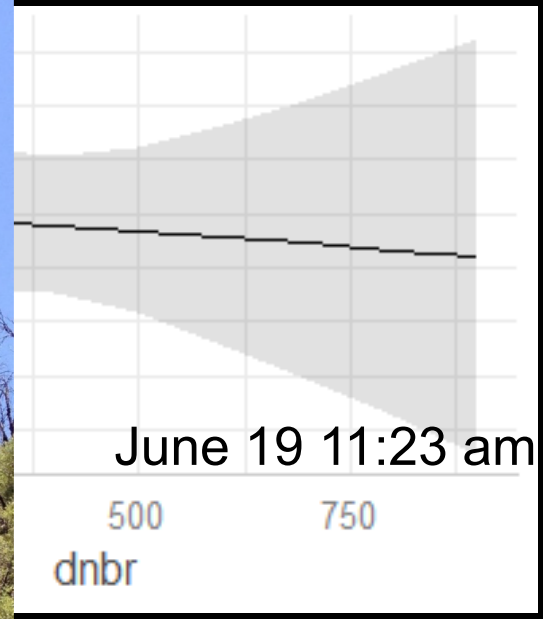
Monthly actual evapotranspiration after high-severity wildfire in northern AZ (2007-2010) measured by eddy covariance (eddy ET) and predicted by MODIS actual ET (2007-2009). (Ha et al. 2015)

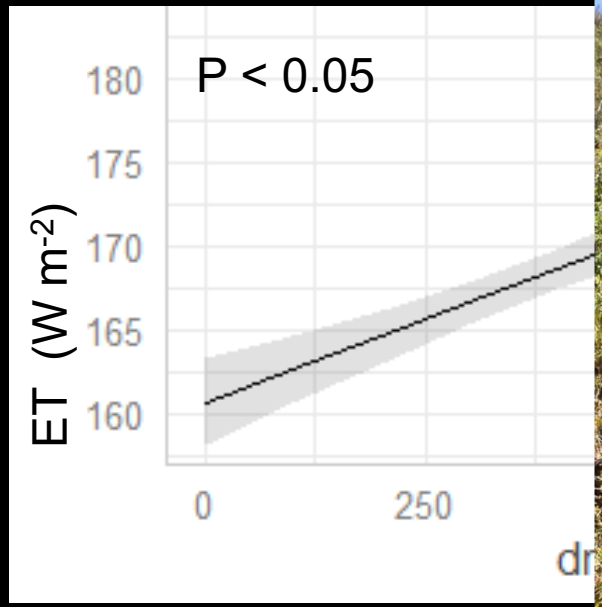
4. Examine how fire severity & post-fire vegetation drive ET & ESI

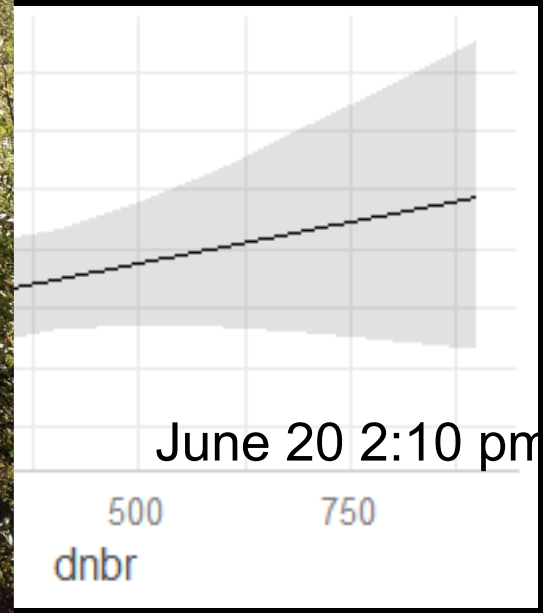
- Extracted dNBR (fire severity) and ET for June 2019, at 1000 random points in CHIR at
  - 9 am
  - 11:30 am
  - 1 pm
  - 2 pm
- Regression models: effect of dNBR (fire severity) on ET




P < 0.05
ET (W m-2)
130
120
110
0
250

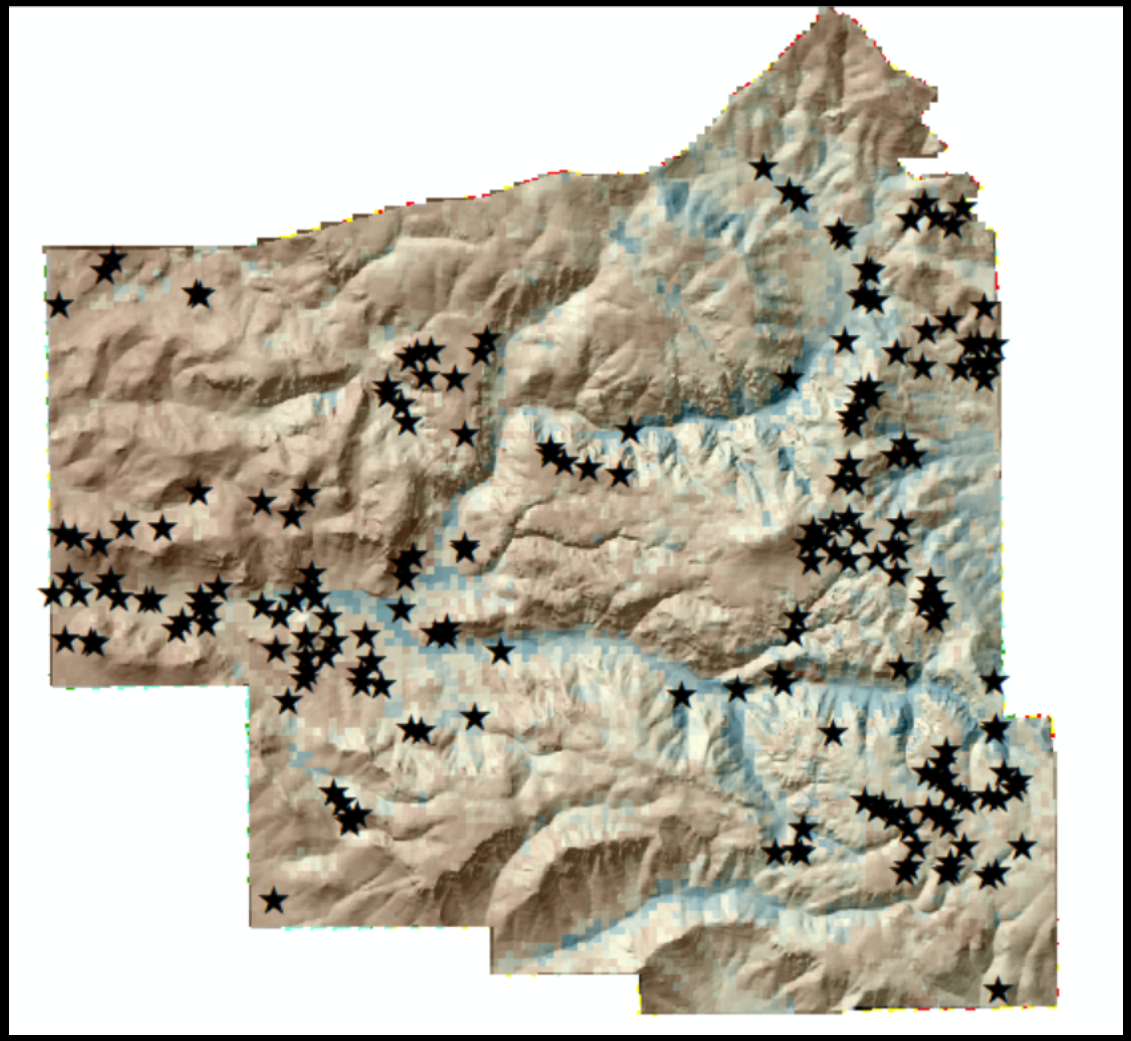

June 19 11:23 am
500
750
dnbr


P < 0.05
ET (W m-2)
180
175
170
165
160
0
250


June 20 2:10 pm
500
750
dnbr

Evaluate how post-fire vegetation structure and composition influence ET and ESI

- 200 vegetation monitoring plots
- Sampled within the last 3 yrs
- 2021 field work to get 10-yr post-fire vegetation response



Thanks! Questions?

ECOSTRESS
ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station
NASA | JPL

NATIONAL PARK SERVICE

WESTERN NATIONAL PARKS ASSOCIATION

JOINT FIRE SCIENCE PROGRAM