Oaks/Grass Savanna AmeriFlux Site in California

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Objectives

- Give Overview of Resources and Metadata
- Report on findings from 16+ years of continuous carbon, water and energy fluxes measured over Oak savanna and annual grassland

Tonzi Ranch, US-Ton, AmeriFlux Tower

Oak Savanna is Perfect Laboratory for Studying Ecosystem-Climate Interactions

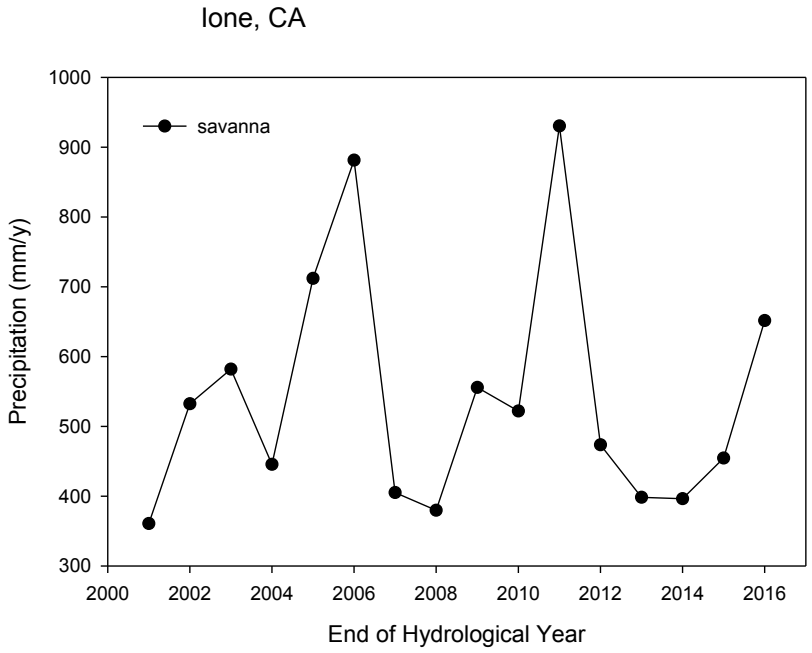
Distinct Wet and Dry Periods, to Study Effects of Varying Soil Moisture on Carbon and Water Exchange

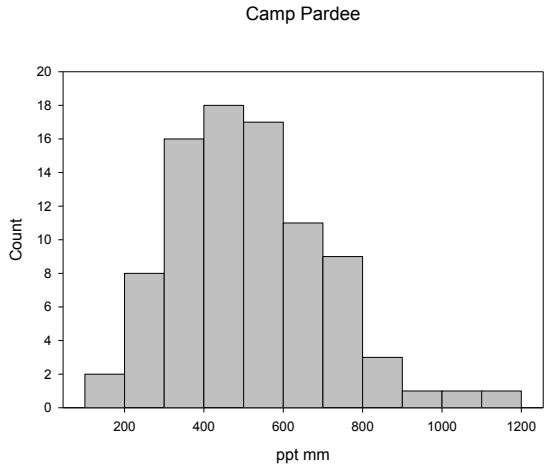
Experiences wide range of Temperature (0-40 C), to study effects of Warming on Ecosystem Processes

Experiences wide range of Annual Precipitation (300-1000 mm), to study non-linear effects of rainfall on ecosystem metabolism

Open Structure Challenges assumptions of Simple Big-Leaf Models

Interannual Variability of Rain at Tonzi/Vaira Ranches

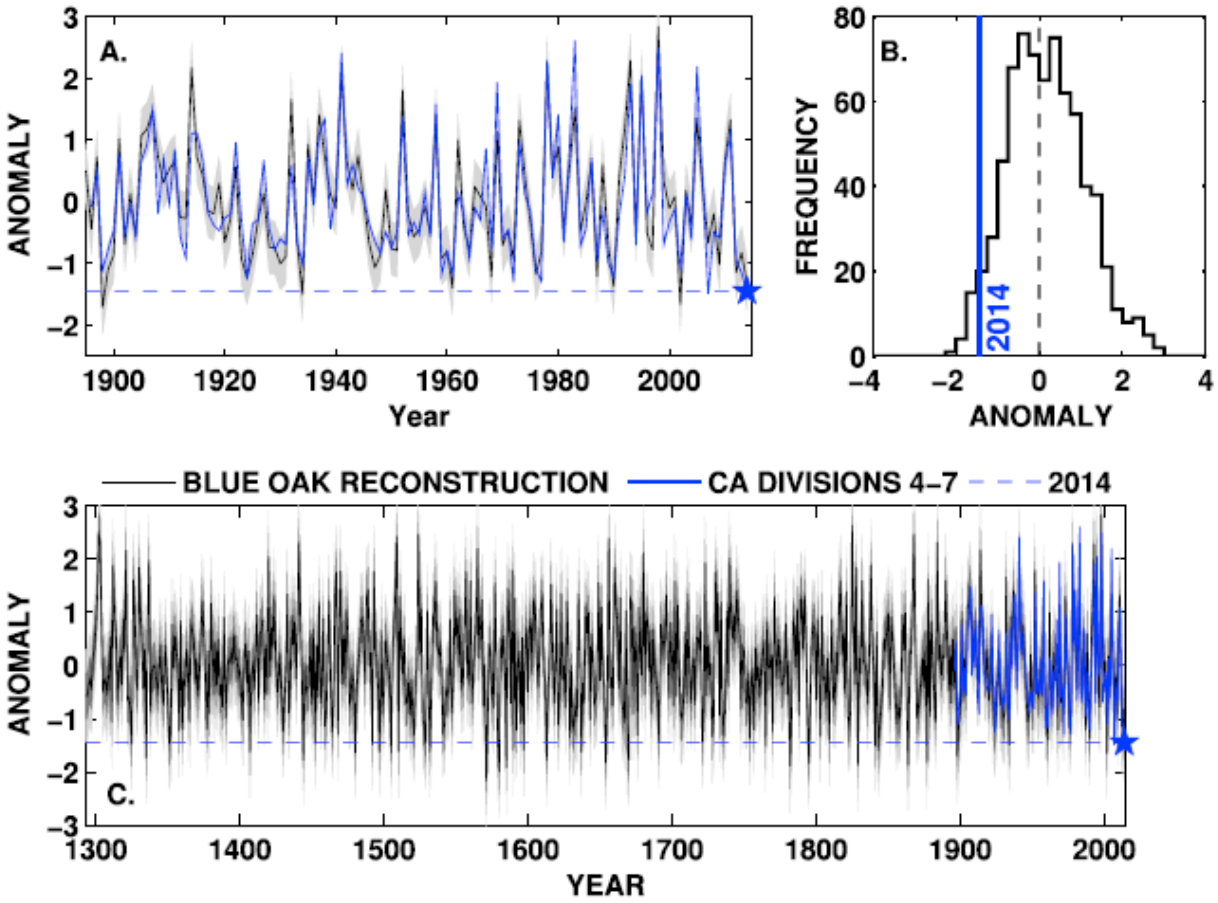




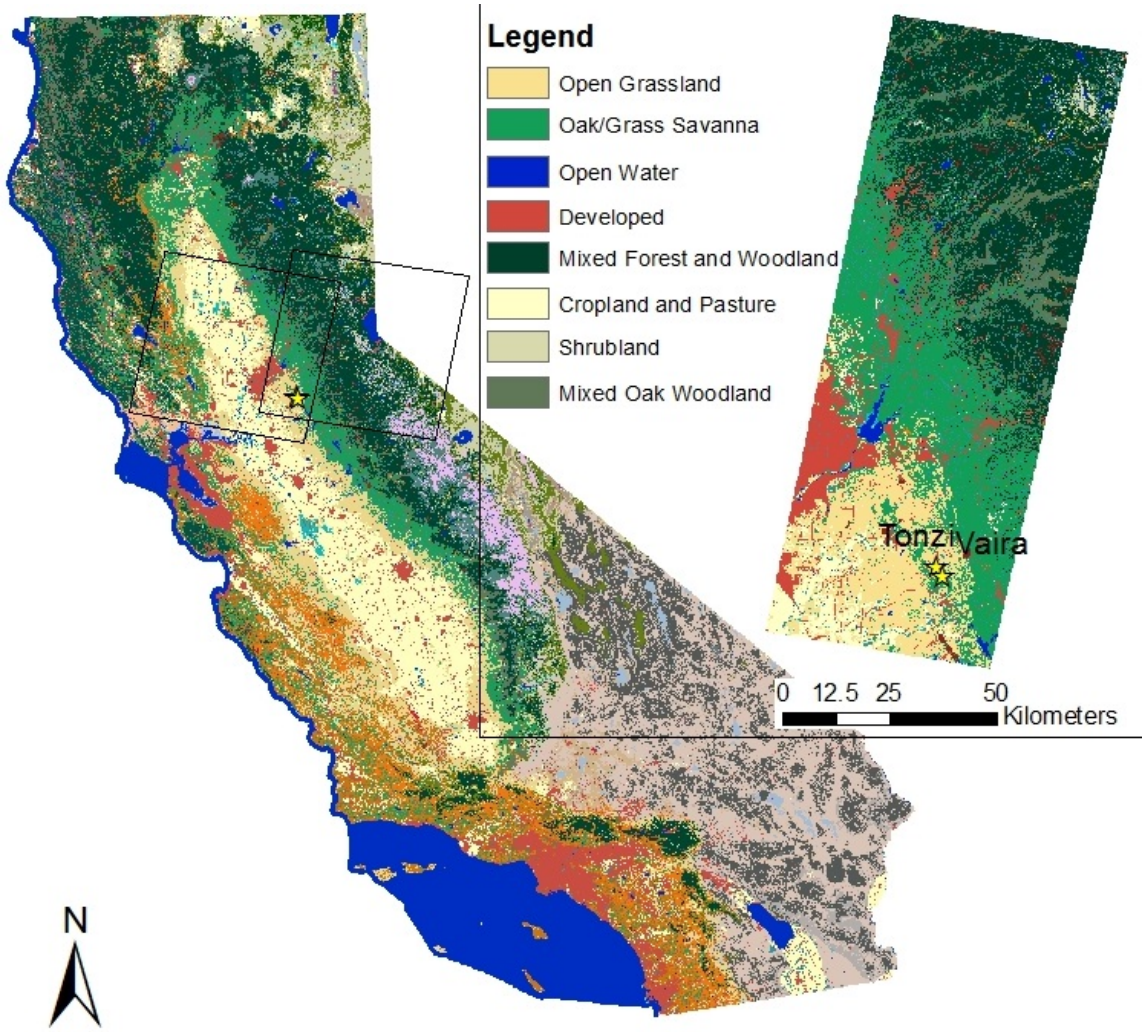
We've Experienced Average and Extremely Wet and Dry Years over the past 16 years

2012/13 were dry but we experienced Dry years before

Oaks are adapted to dry years and can survive 2 dry years in a row.
What about 3 dry years in a row?
They tend to occur rarely.



Griffin + Anchukatis, 2015 GRL

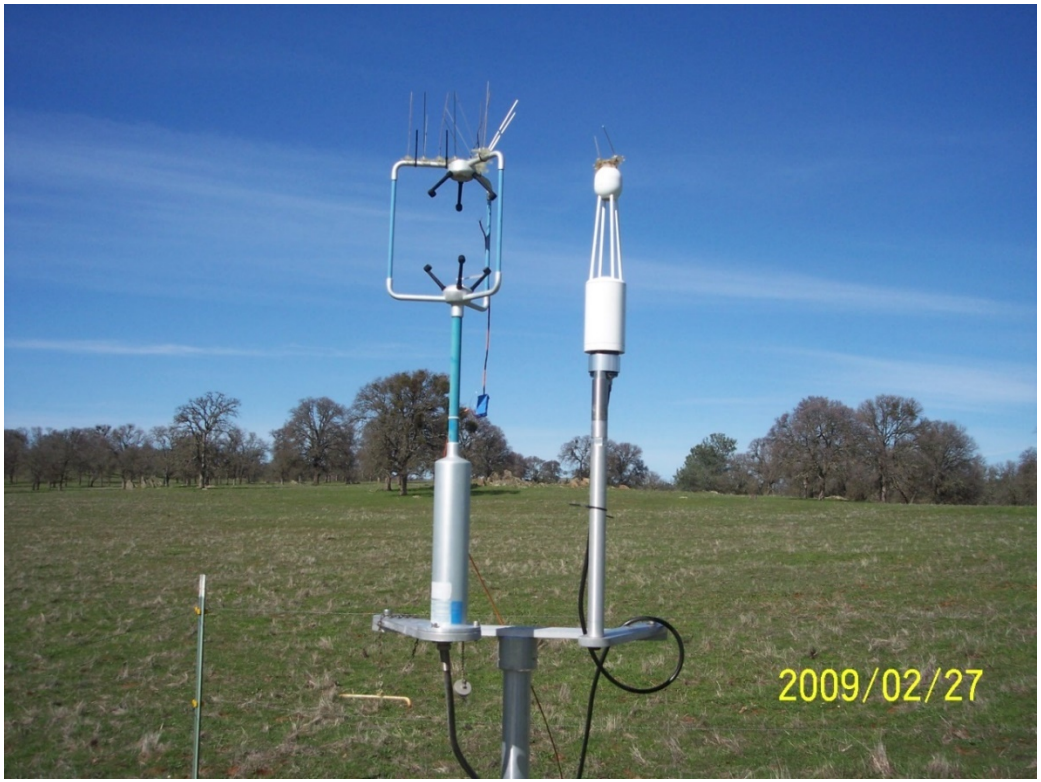


Liu, Y., M. J. Hill, X. Zhang, Z. Wang, A. D. Richardson, K. Hufkens, G. Filippa, D. D. Baldocchi, S. Ma, J. Verfaillie, and C. B. Schaaf. 2017. Using data from Landsat, MODIS, VIIRS and PhenoCams to monitor the phenology of California oak/grass savanna and open grassland across spatial scales. Agricultural and Forest Meteorology **237–238**:311-325.

Modis Operandi

- Direct Carbon, Water and Energy Flux Measurements with Eddy Covariance
- Spatial Upscaling with Remote Sensing
  - Terrestrial and Airborne LIDAR, IKONOS (1-4 m resolution)
- Temporal Upscaling with Digital Cameras and Veg Indices
  - Phenology and Dynamics of Leaf Area Index
- Mechanistic Understanding of Ecophysiological Processes
  - Understory eddy flux system and soil CO2 probes for flux partitioning
  - Ecosystem Modeling, CANOAK-3D
  - Physiological Measurements of Pre-Dawn Water potential and photosynthetic capacity, TRY
  - Soil moisture networks, COSMOS, SMAP, ISMN
  - Root and Soil Depth, with GPR

Eddy Flux Instrumentation

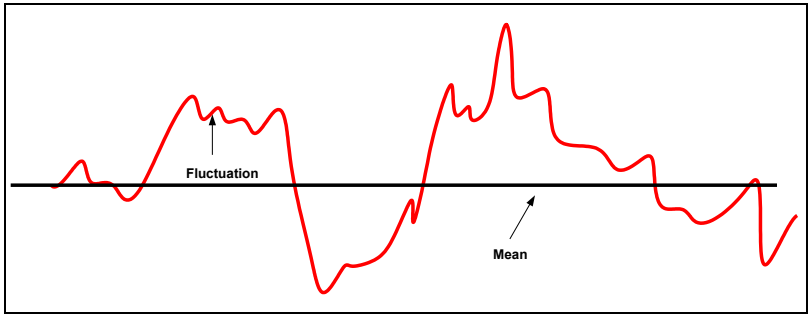


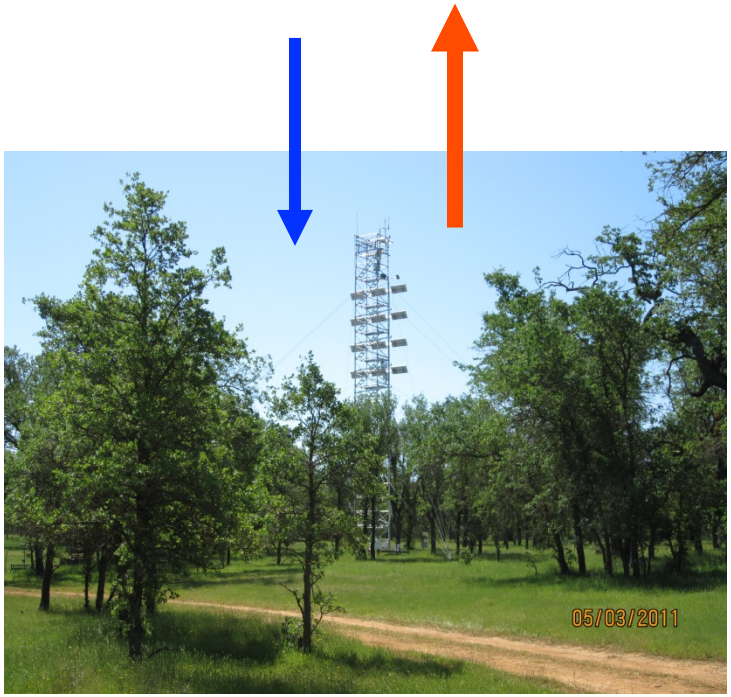
3d Sonic Anemometer

Non Dispersive Infrared Gas Spectrometer for CO_2 and H_2O

Eddy Covariance

$$F = \overline{w'c'}$$

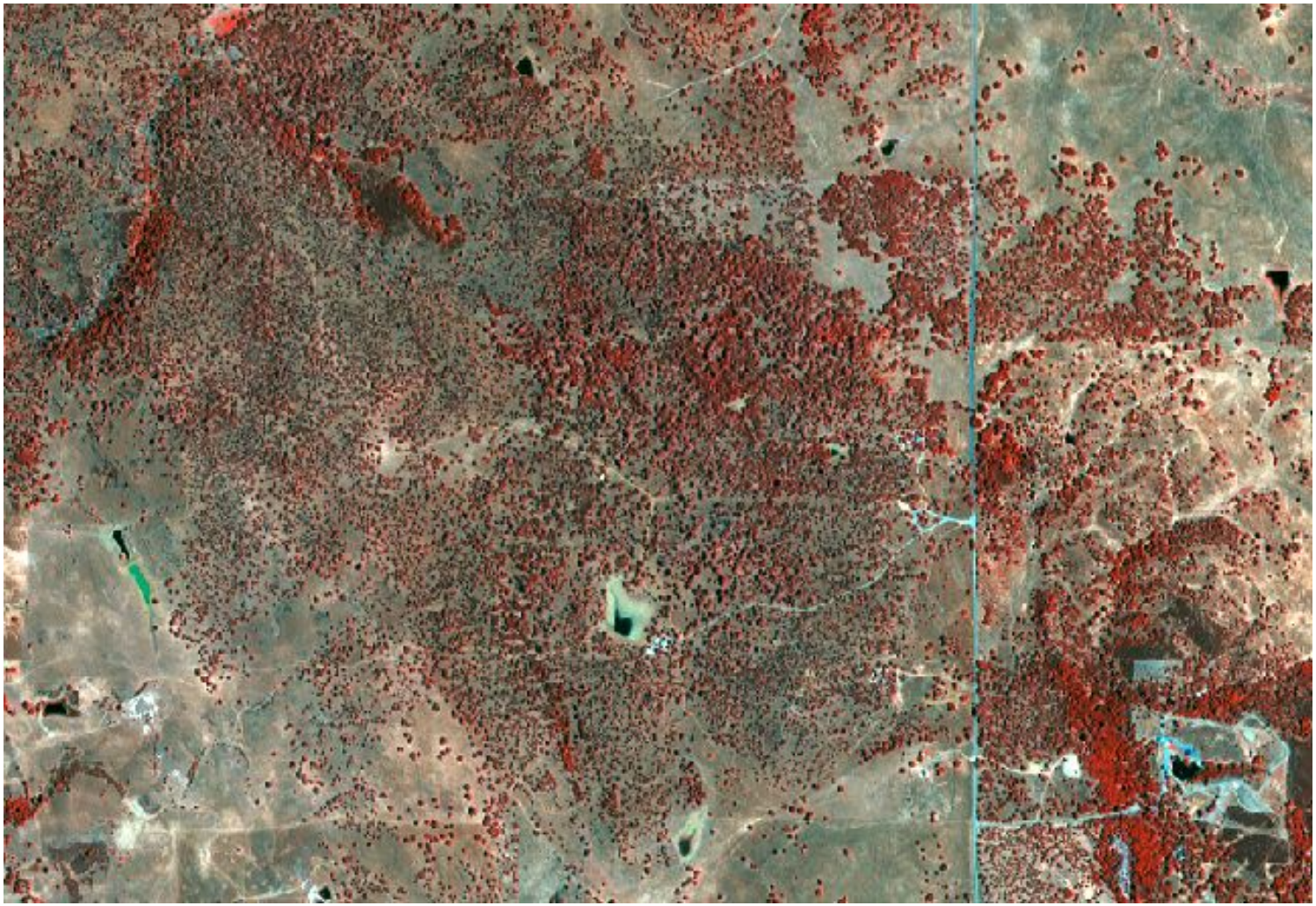




Repository of Remote Sensing Data

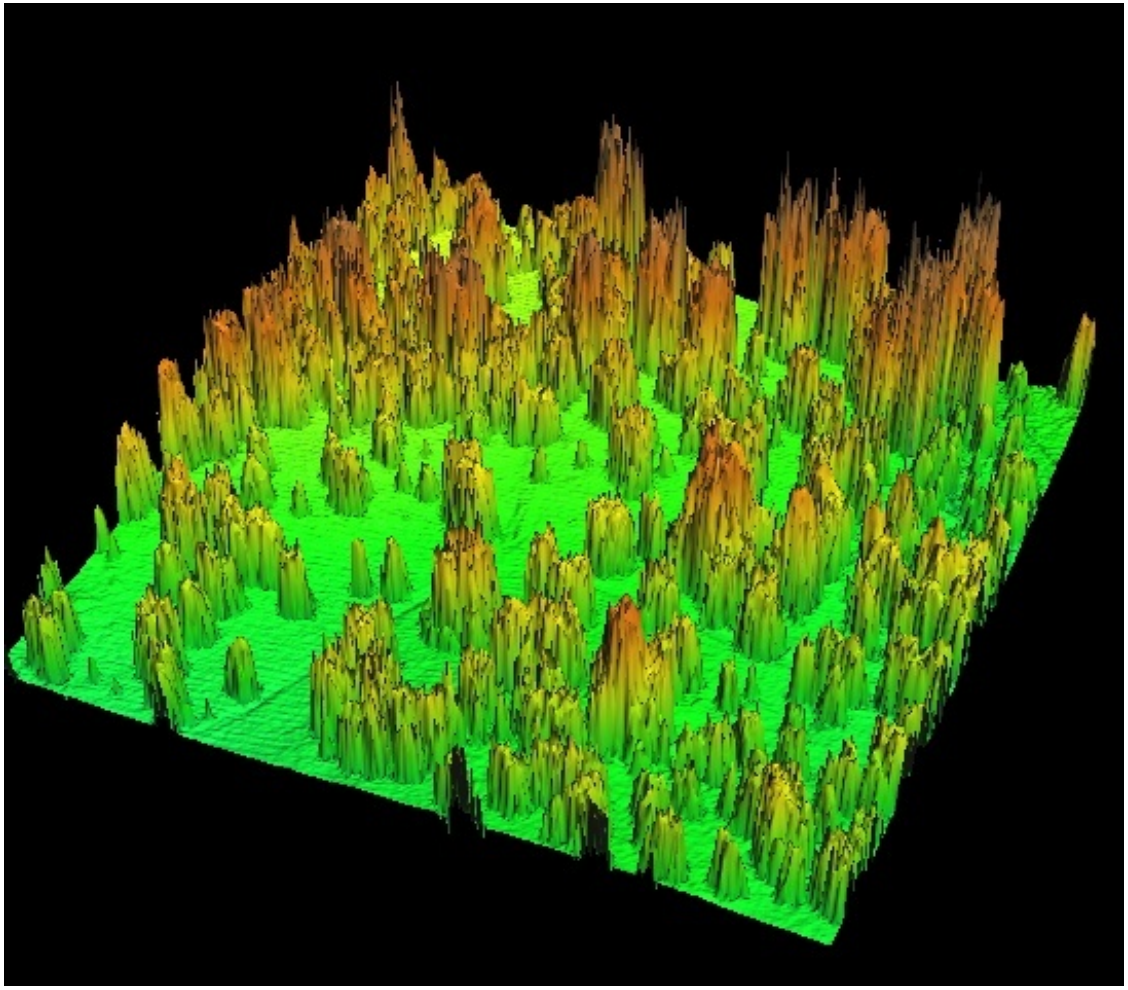
- Ikonos: 07/22/2001
- Avris: 2005, 2006, 2009
- CASI:
- Airborne LIDAR: 2003, 2009
- Terrestrial Lidar: 2014
- MODIS Time Series…
- Upward Looking Digital Camera time series: 2006-
- LED/NDVI time series: 2006->
- High Resolution spectral reflectance time series (2006-)
- Understory Tram System (PAR and Rn in x): 2006-2015
- Tower-based Digital Web Camera: 2005->

Tonzi Ranch Oak Savanna, near Ione

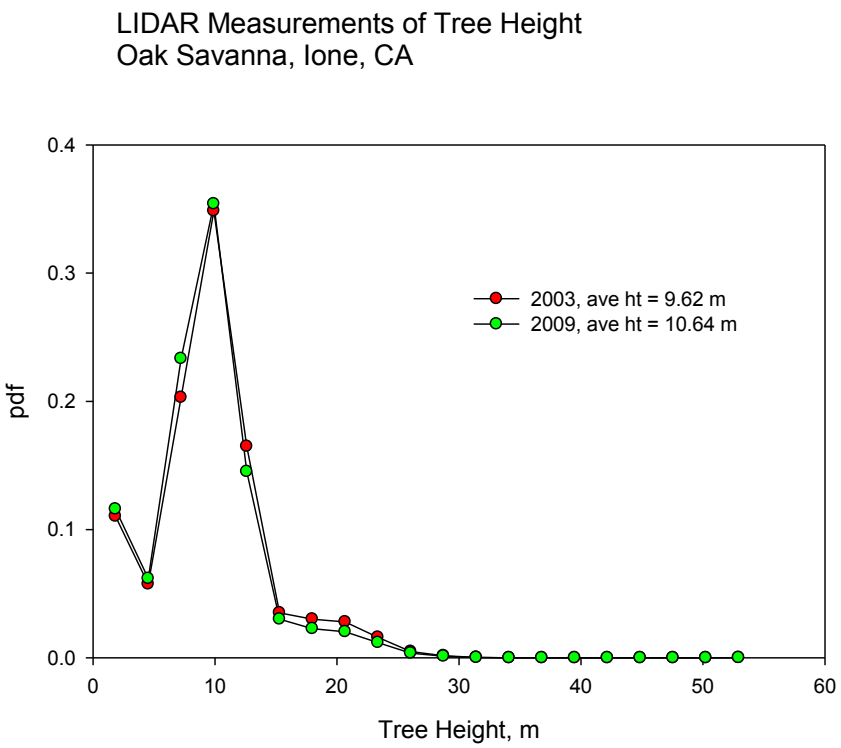


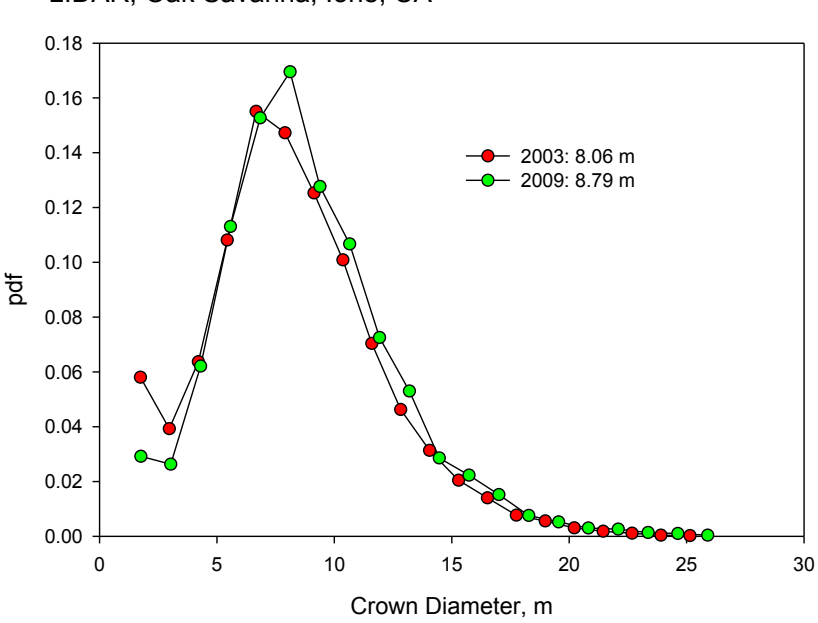
IKONOS

Canopy Structure: Laser Altimeter Data



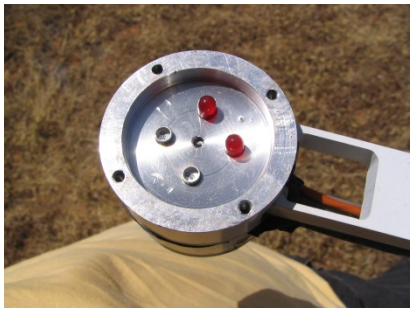
Chen et al


LIDAR Measurements of Tree Height
Oak Savanna, Ione, CA
pdf
Tree Height, m
2003, ave ht = 9.62 m
2009, ave ht = 10.64 m
0.0
0.1
0.2
0.3
0.4
0
10
20
30
40
50
60


LIDAR, Oak Savanna, Ione, CA
pdf
Crown Diameter, m
2003: 8.06 m
2009: 8.79 m
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0
5
10
15
20
25
30

Beland et al

Monitor Surface Phenology with a Suite of Optical Sensors



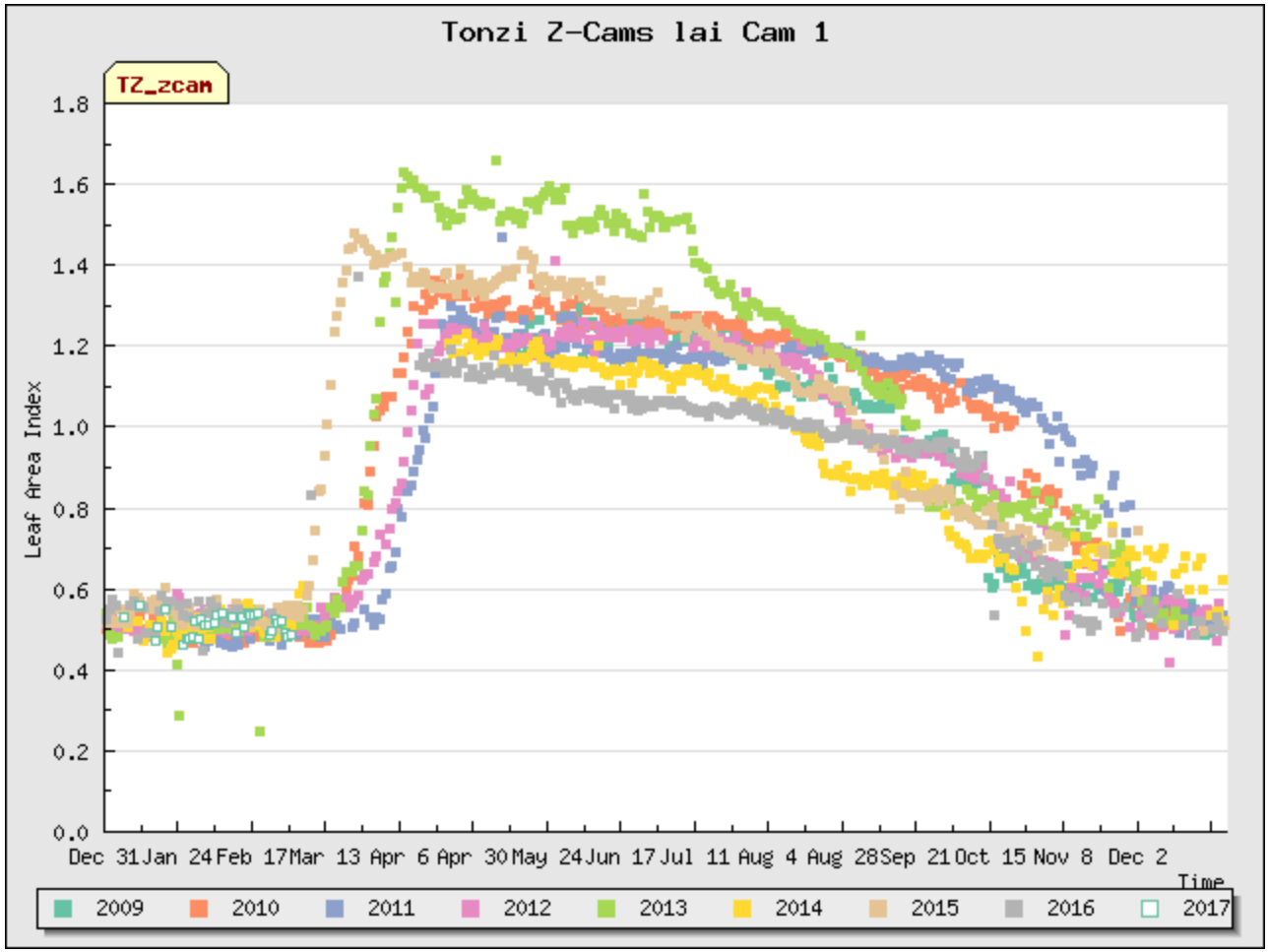
LED NDVI Sensor

Flux Tower with Digital Camera

Hyper-spectral spectrometer

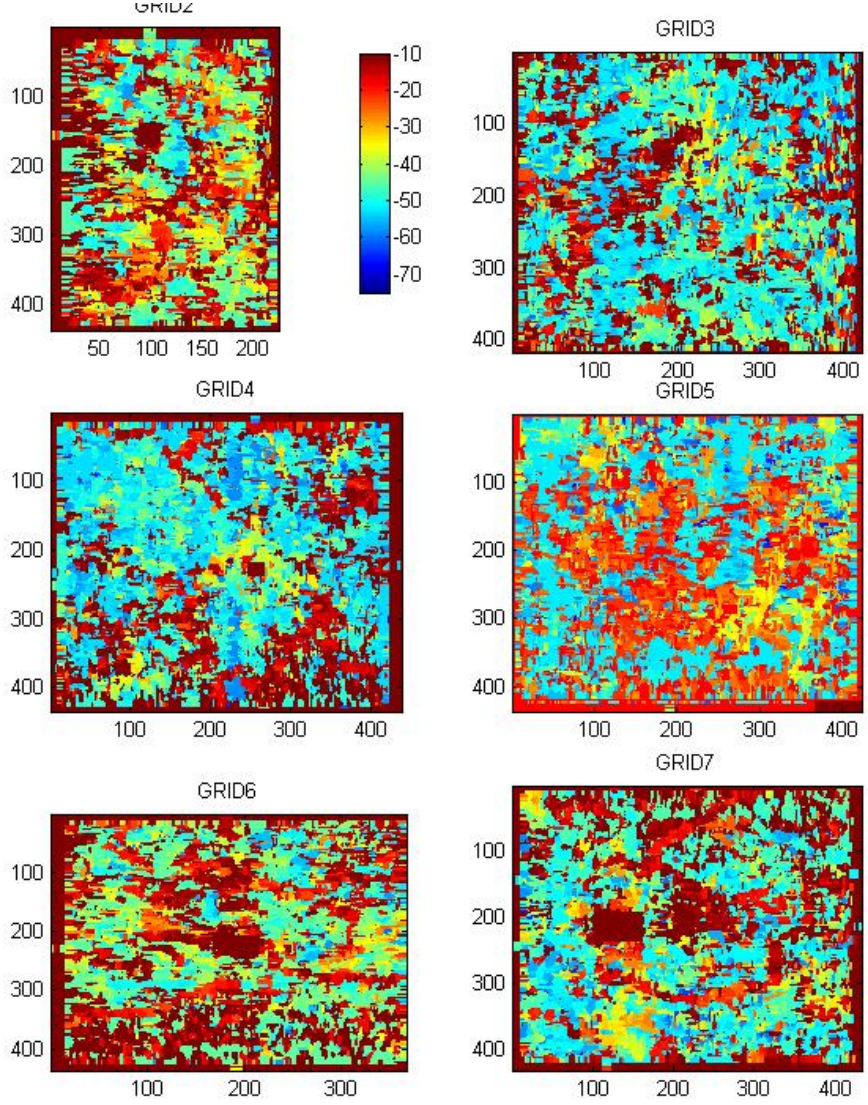
Upward Looking Camera

Gap Fraction Phenology with Upward Looking Cameras under Oak Savanna



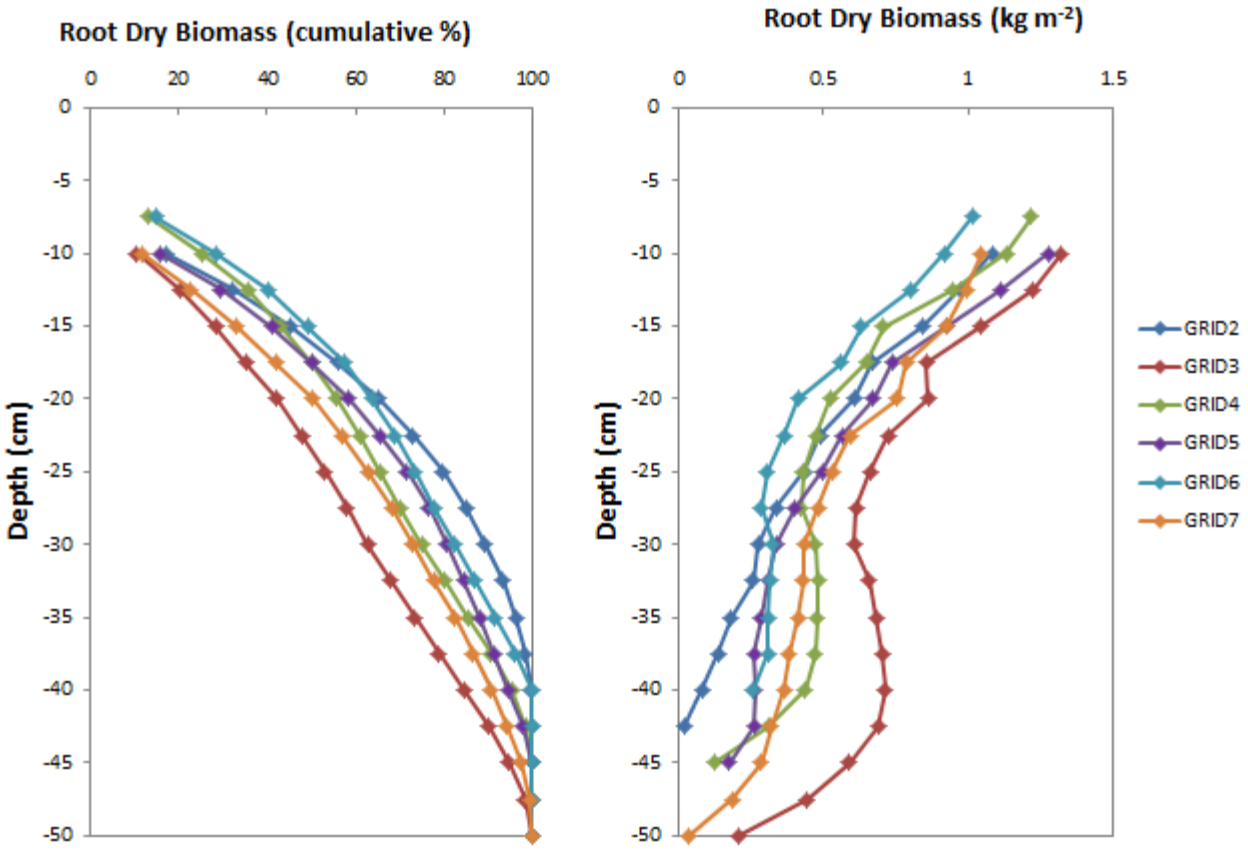
Can Detect Start and End of Growing Season with Precision

Soil Depth with Ground Penetrating Radar

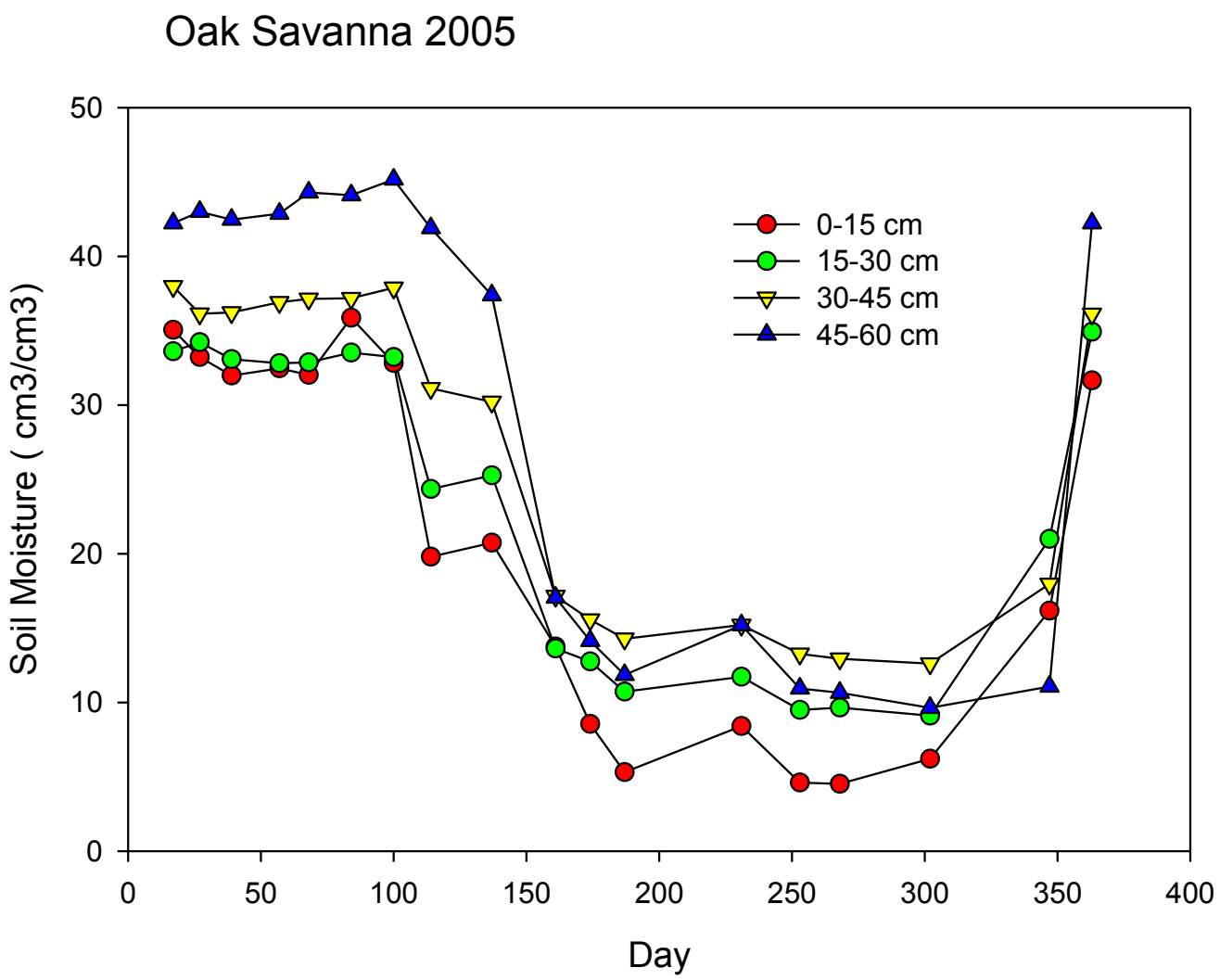


Raz-Yaseef et al, 2013 JGR Biogeoscience

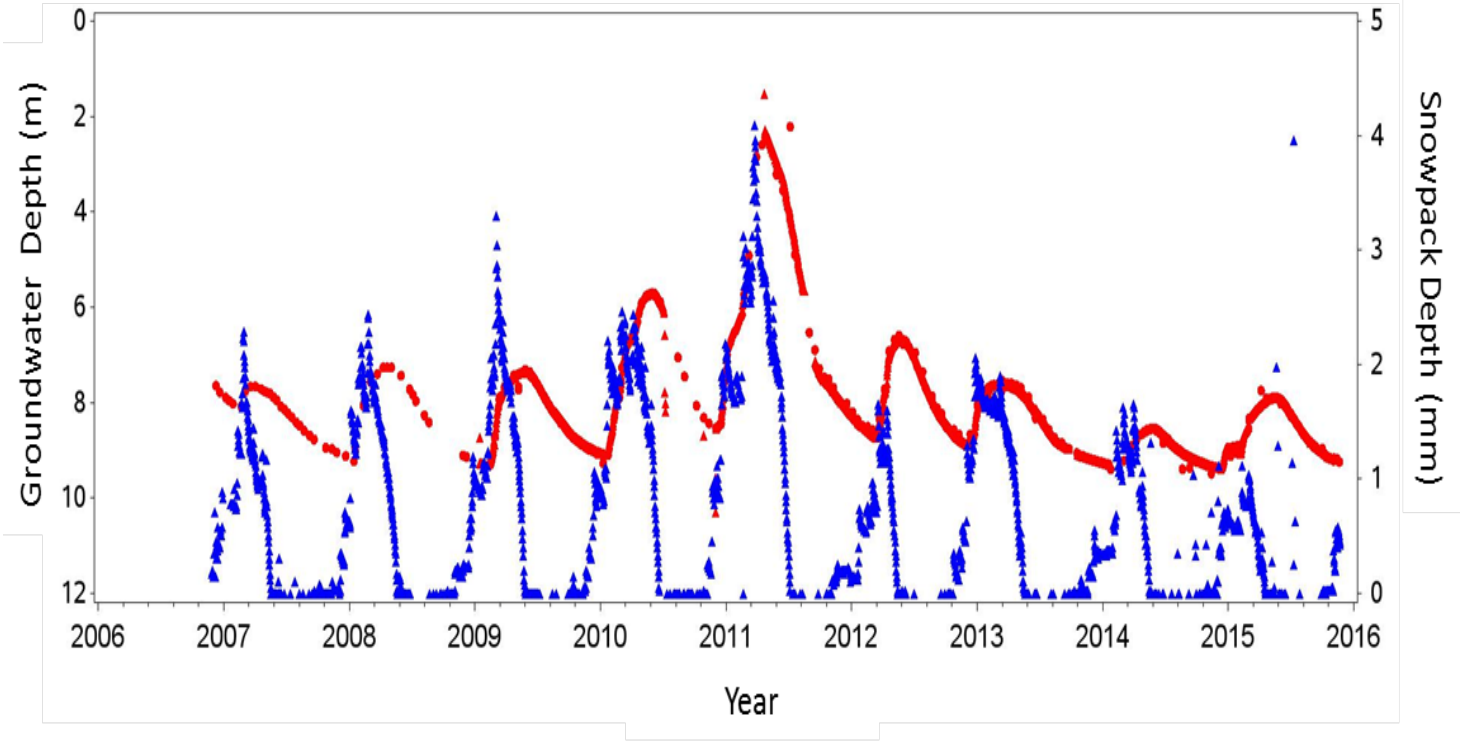
Roots!


Root Dry Biomass (cumulative %)
0
20
40
60
80
100
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Depth (cm)
Root Dry Biomass (kg m-2)
0
0.5
1
1.5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Depth (cm)
GRID2
GRID3
GRID4
GRID5
GRID6
GRID7

Seasonality of Soil Moisture

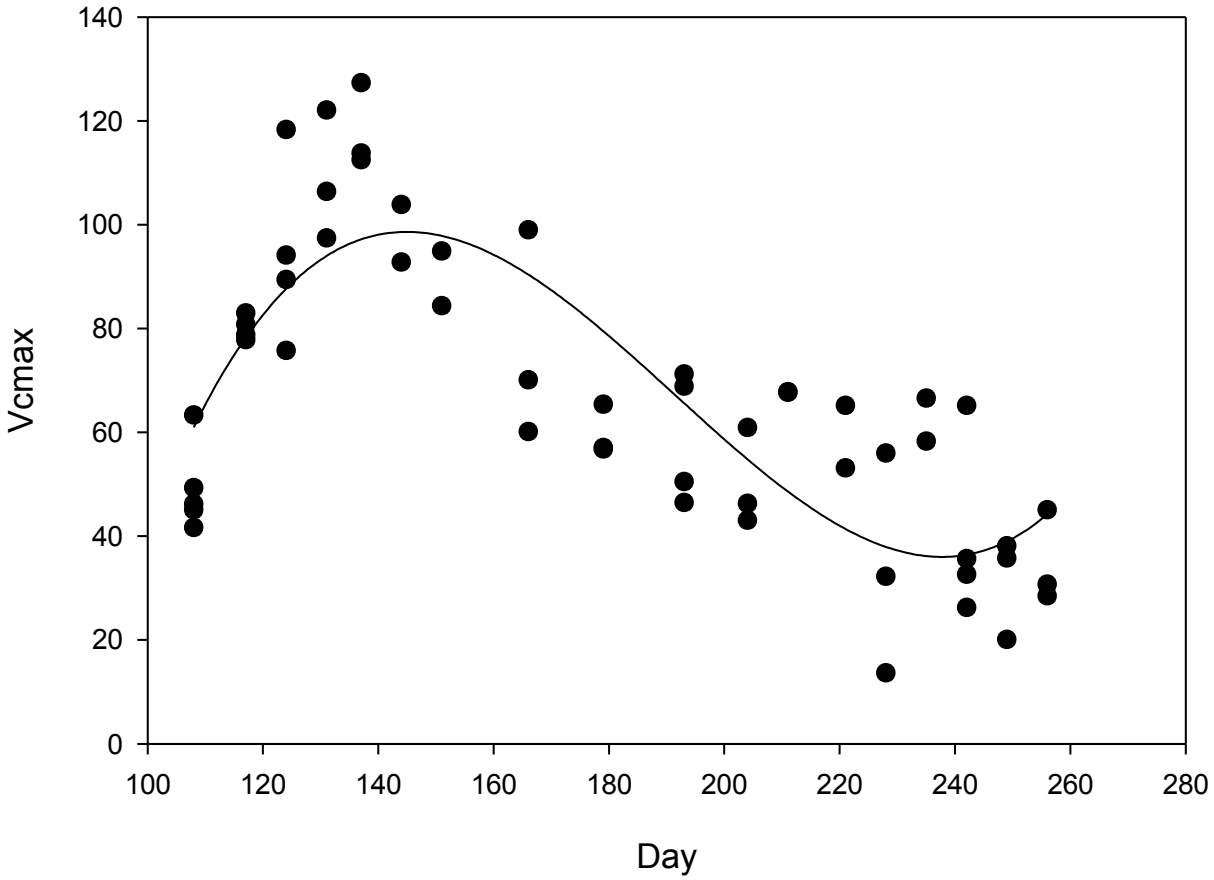


Monitoring Depth to Ground Water

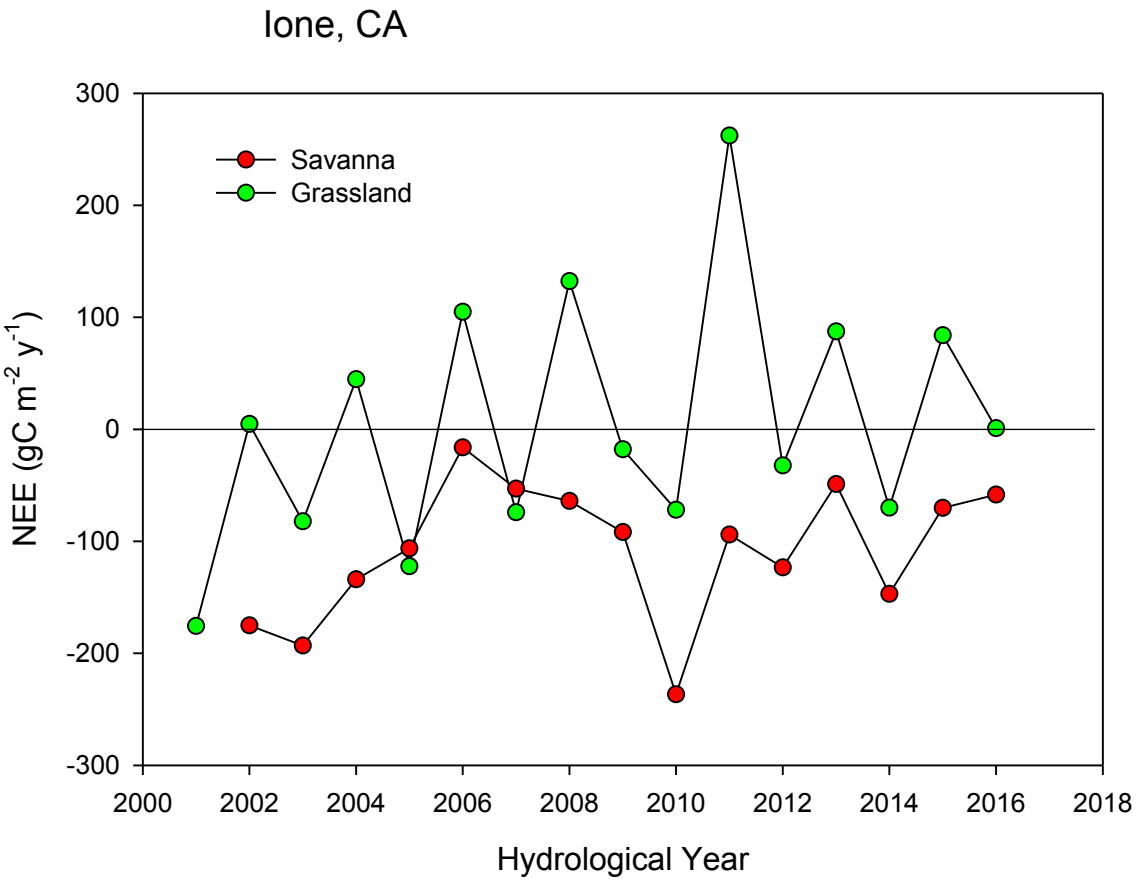


Ma et al. 2016 AgForMet
Miller et al, 2010, WRR

Seasonality of Photosynthetic Capacity



Interannual Variability of Net Ecosystem Carbon Exchange



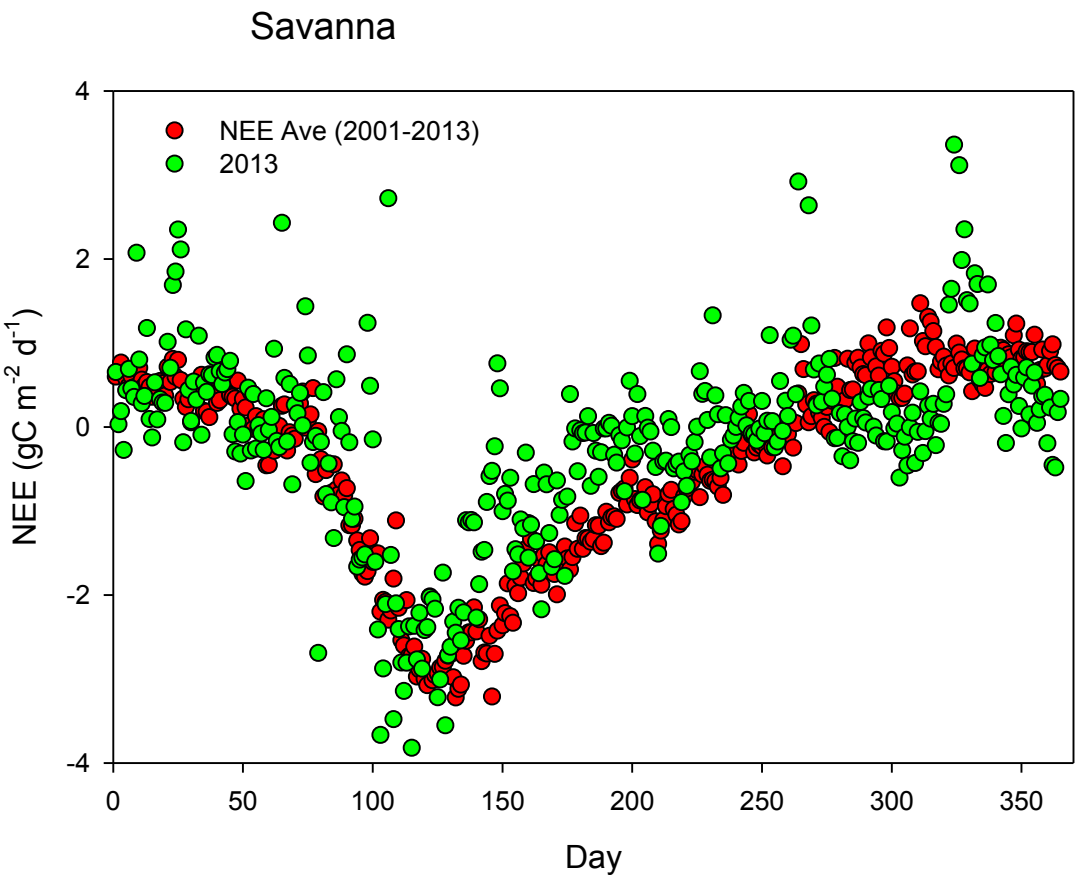
Tonzi Ranch

Vaira Ranch

Grassland is Carbon Neutral, a slight source: 27 gC m^{-2} y^{-1}

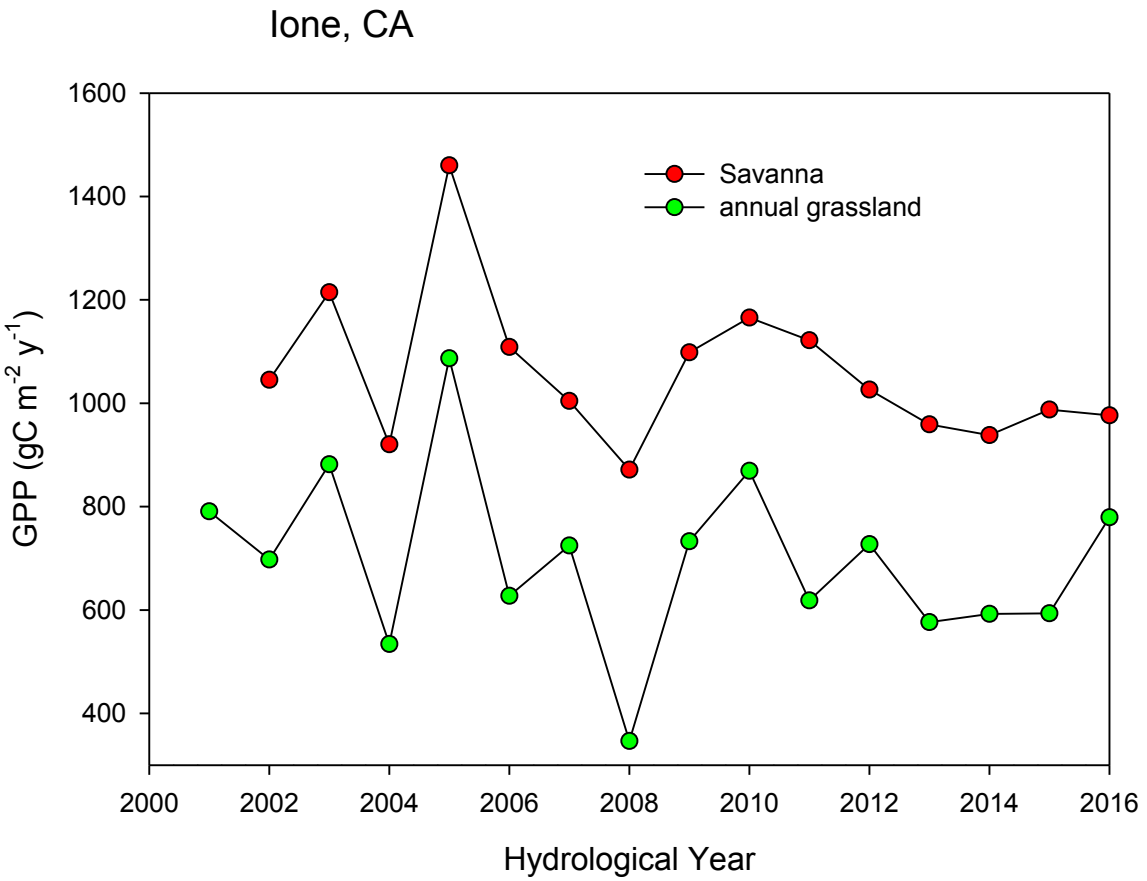
Savanna is a modest Sink,: -157 gC m^{-2} y^{-1}

Effect of Drought



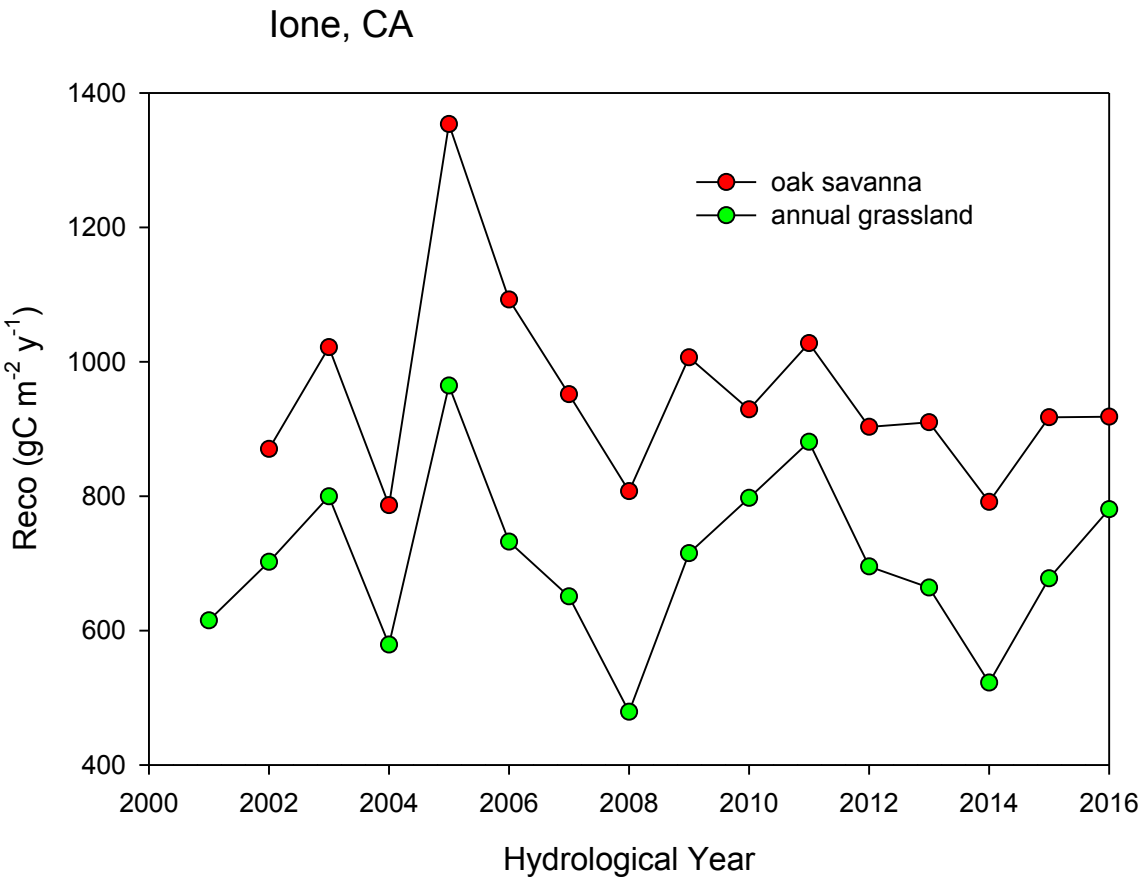
2013 was Normal until about D120, then System shut down, Physiologically

Variation in Gross Primary Productivity



Savanna (1060 gC m^{-2} y^{-1}) was more productive, by 40%, than the Grassland (665 gC m^{-2} y^{-1})

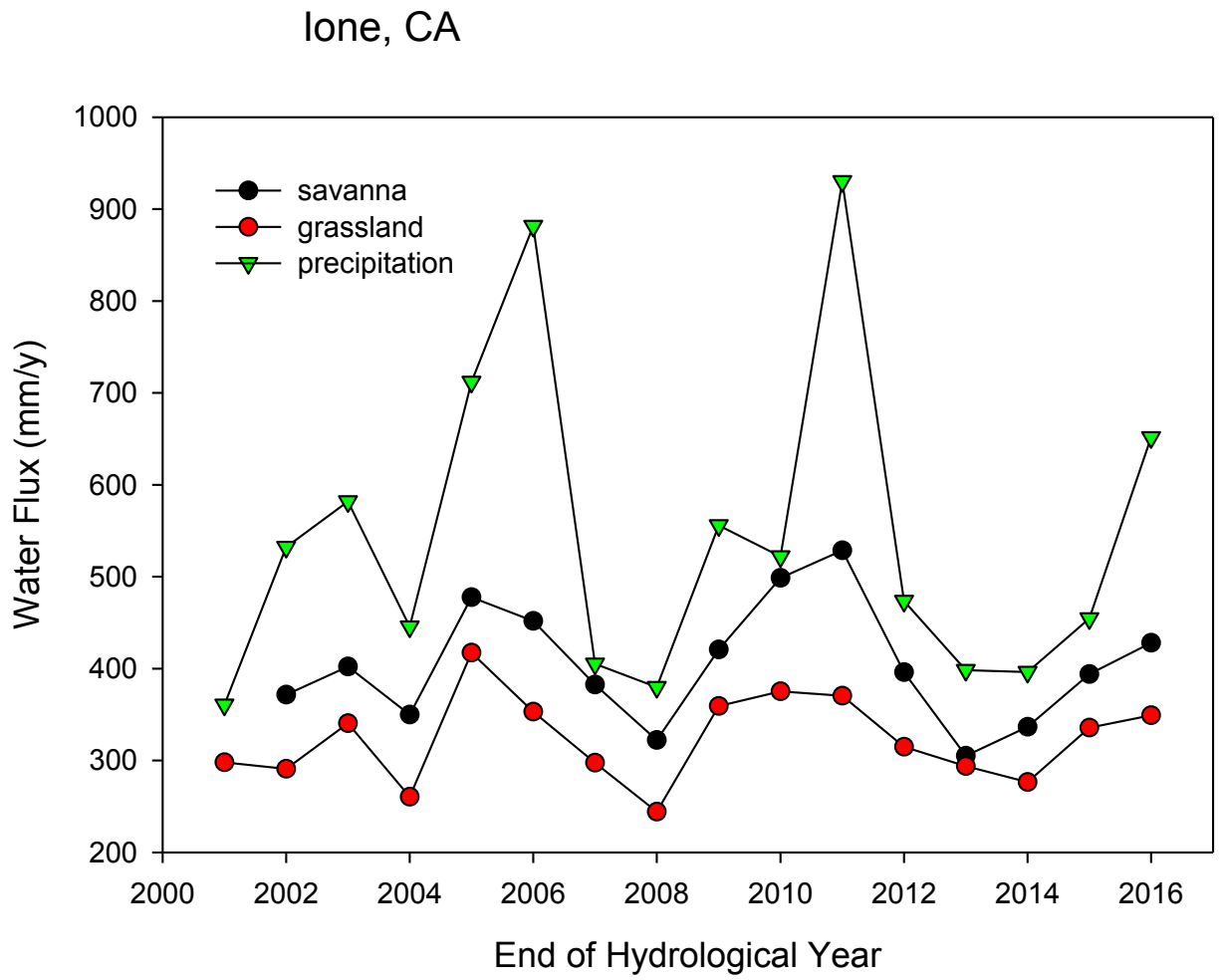
Variation in Ecosystem Respiration



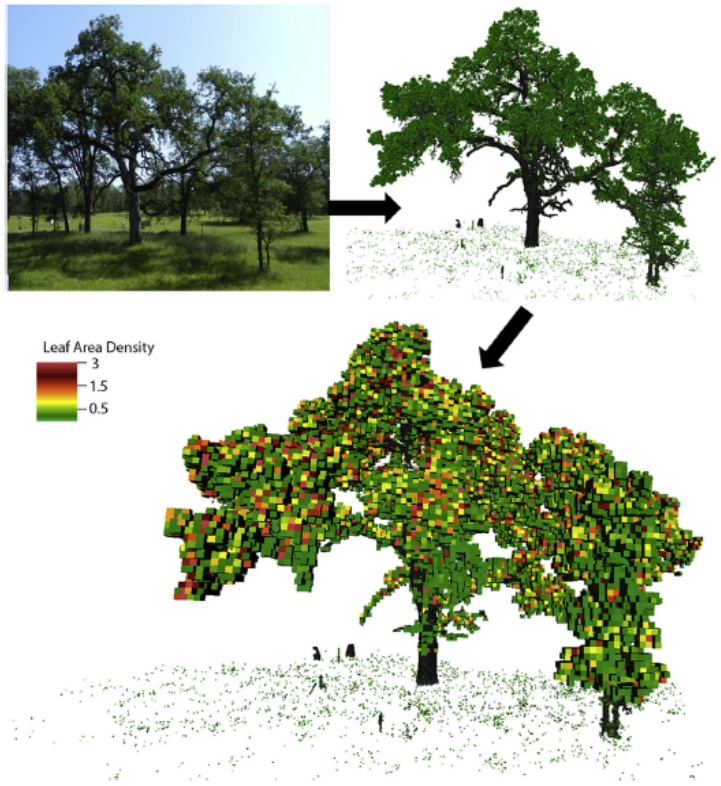
The ‘cost’ of a more Productive System

Rain and Evaporation

Savanna ET: 404 +/- 64 mm y^{-1}
Annual Grass ET: 323 +/- 26 mm y^{-1}
ppt: 542 +/- 173 mm y^{-1}



On-Going Work



Work Continues at part of AmeriFlux and FLUXNET networks

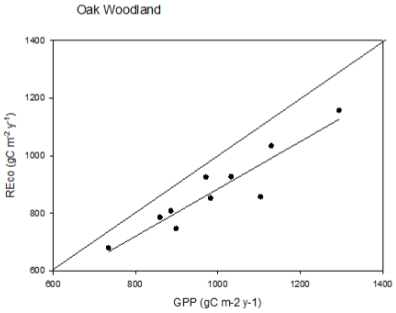
Use Terrestrial Lidar to Characterize Canopy and Apply 3-d Models to Simulate Light, carbon and Water Exchange

Collaborating with COSMOS and SMAP projects To detect soil moisture dynamics with remote Sensing and microwave band radar

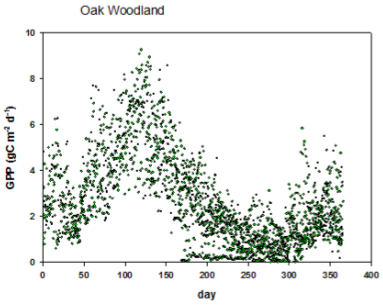
Data are Widely Used in Validating Models, Remote Sensing Products and Cross Site Syntheses

Life as a Blue Oak: Fitting through the Evolutionary Eye of the Needle

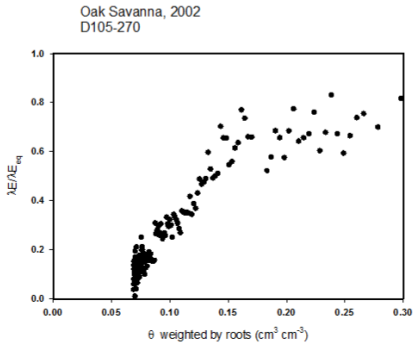
Photosynthesis > Respiration



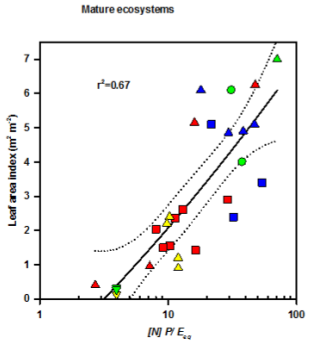
Photosynthesis is Inhibited during the Summer Growing Season due to Soil Moisture Deficits



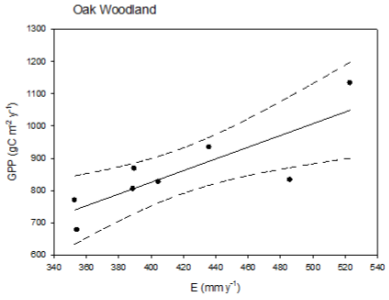
Reductions in Soil Moisture Induces Stomatal Closure, which Deficits Down-Regulates Evaporation...and Photosynthesis



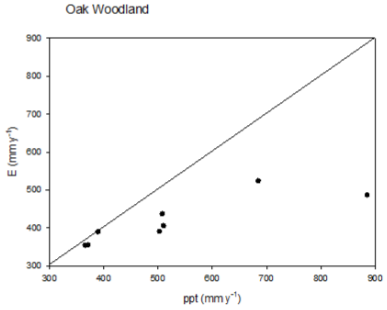
Water Budget Constrains Leaf Area Index that is Sustained



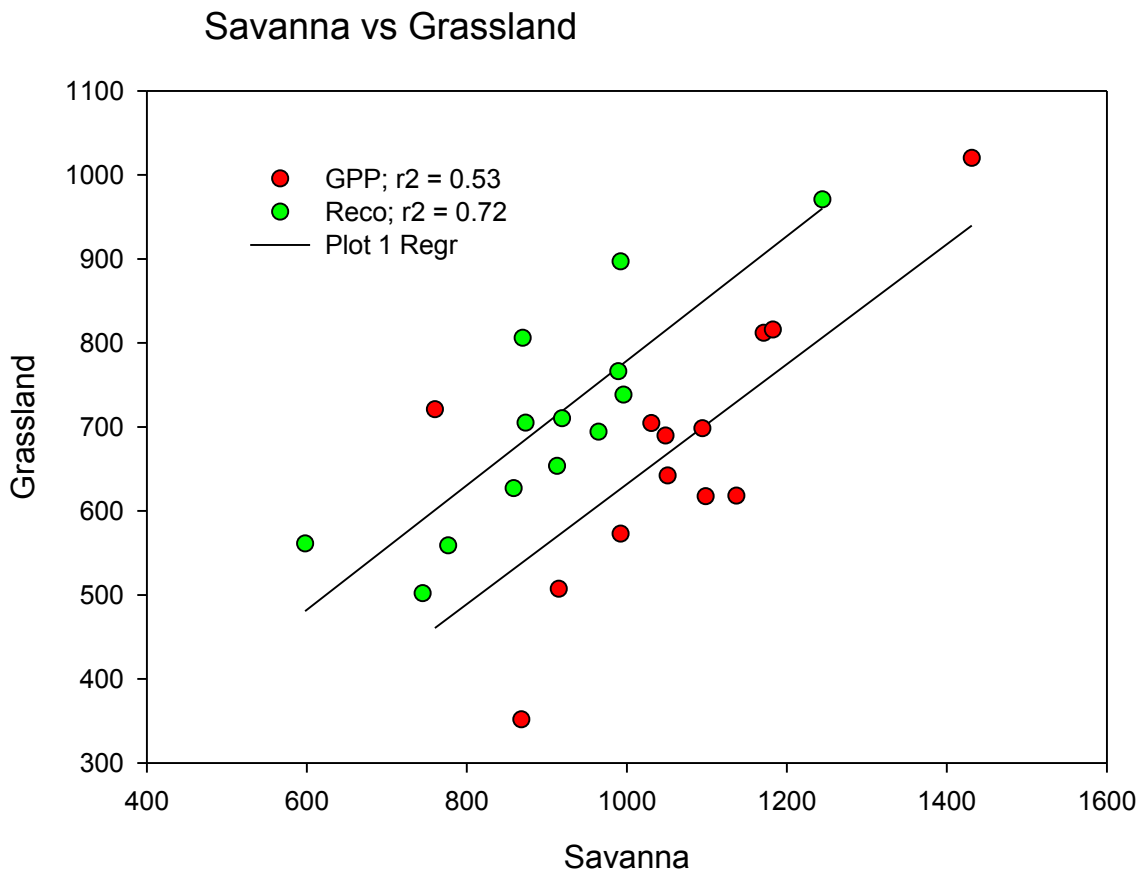
Photosynthesis Scales with Evaporation



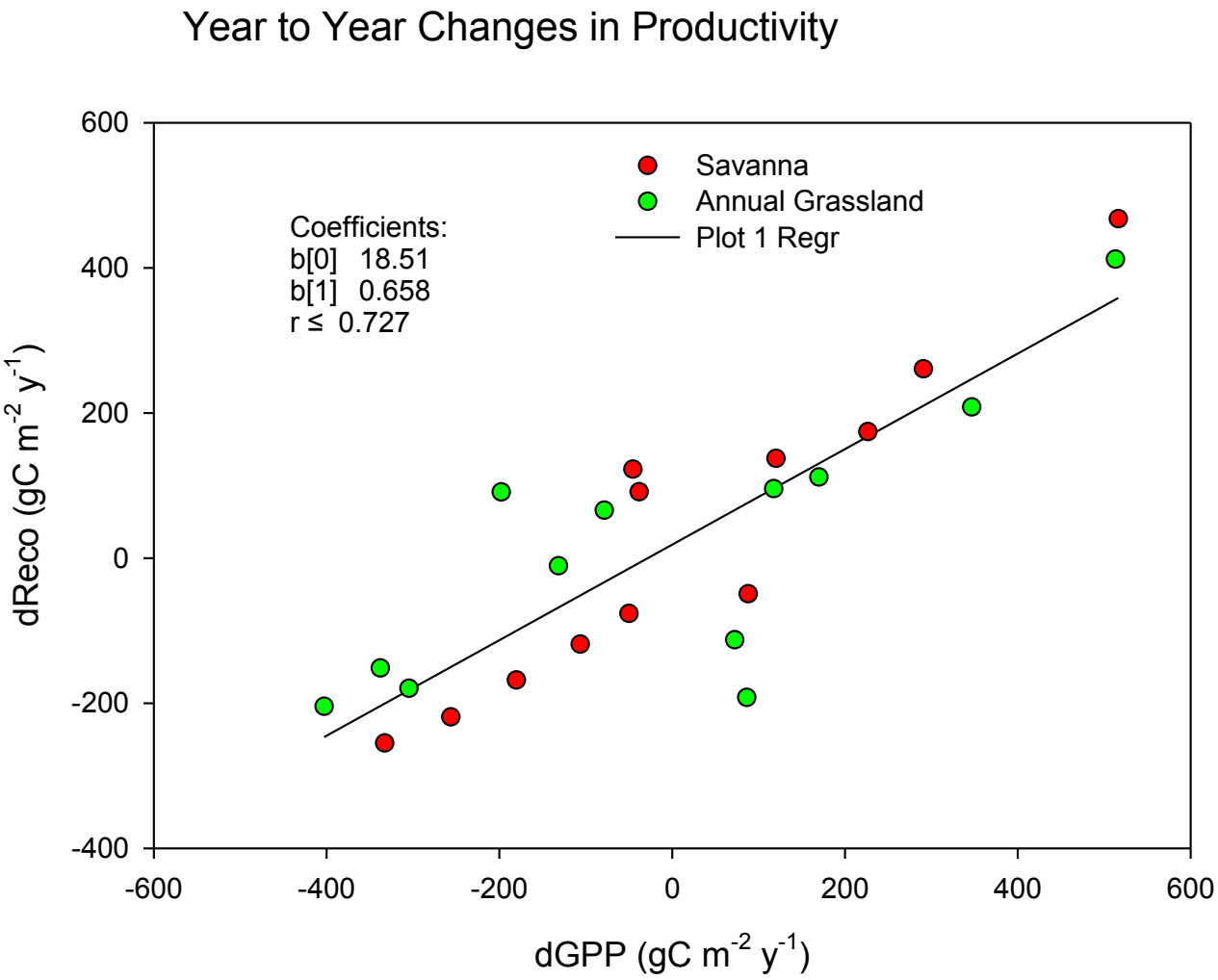
Evaporation < Precipitation



Carbon Fluxes at the Savanna and Grassland are in Synch



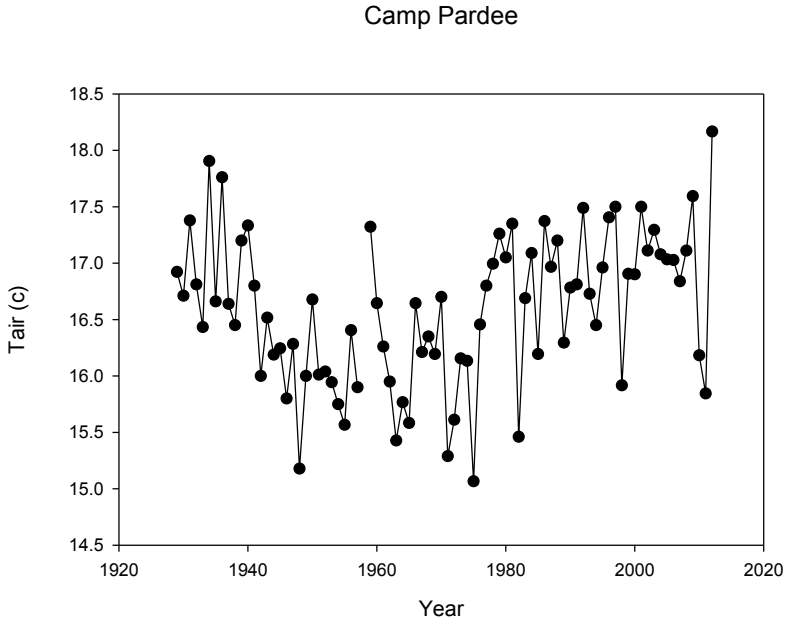
Years that Promote Productivity, relative to the Prior year Come at the Cost of More Respiration, And Vice Versa

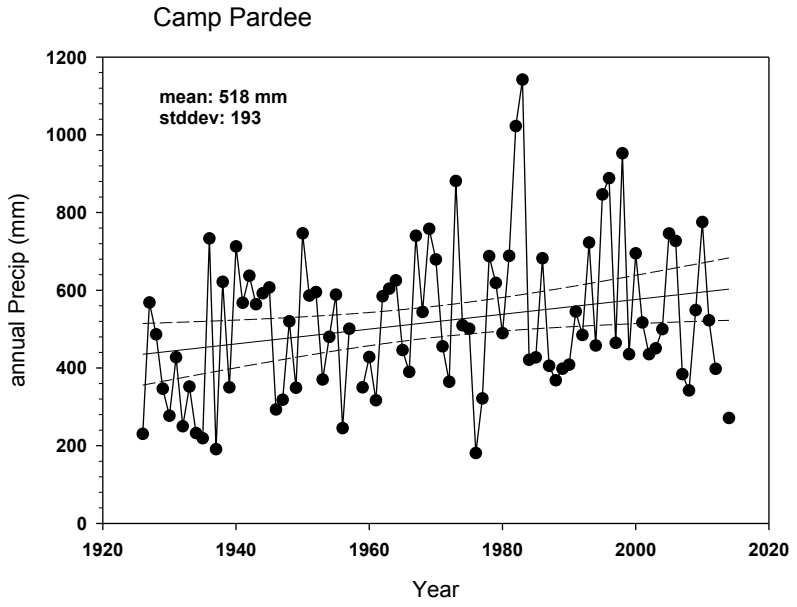
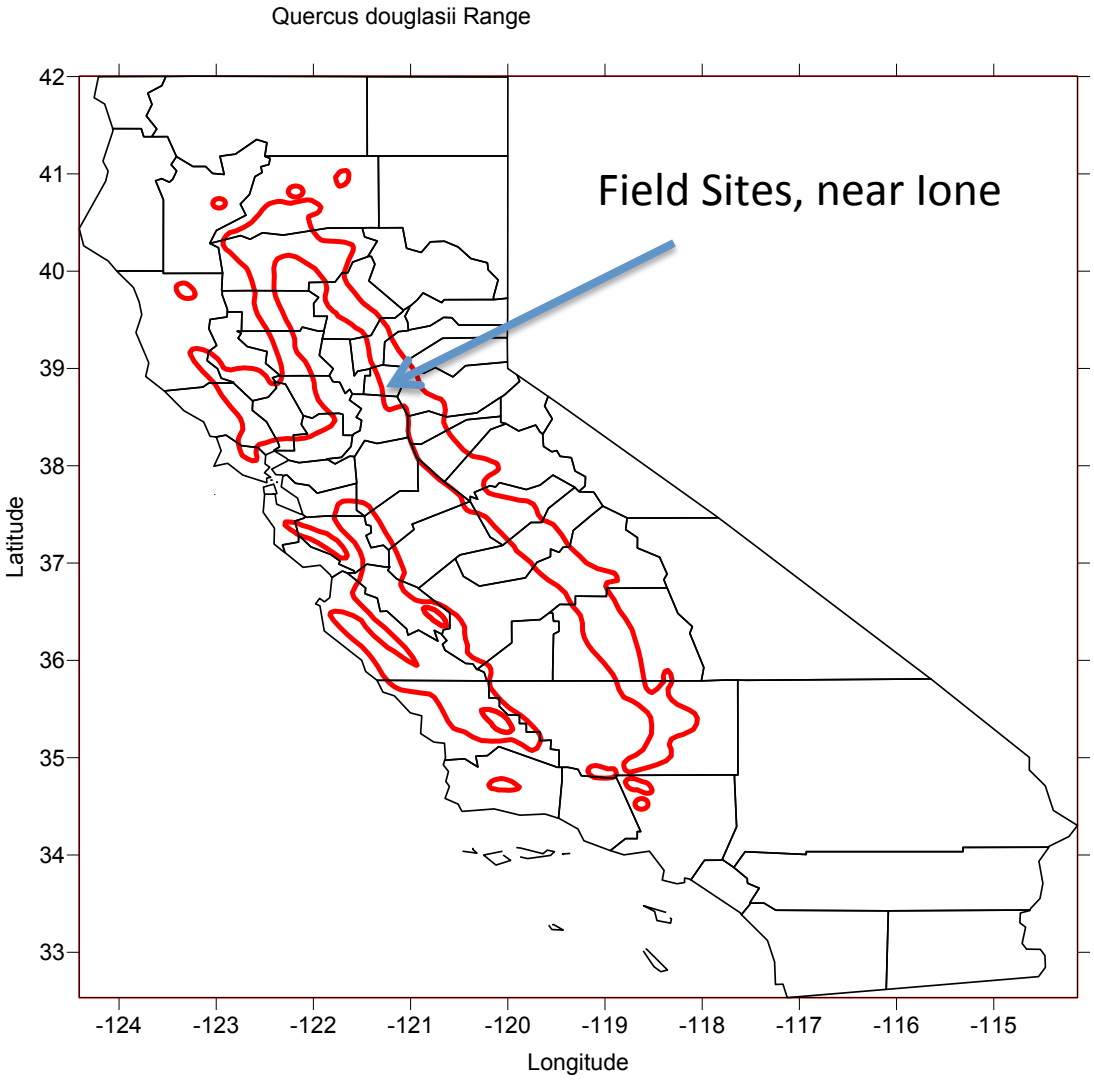


Climate Trends:
Pardee, CA

Temperature Increased by about 1.25 C over 60 Years

Precipitation is Highly Variable and Near the Borderline to Sustain Forests vs Grass





Blue Oak Range