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
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 CO2 and H2O
Eddy Covariance

\[ F = \overline{w' c'} \]
Repository of Remote Sensing Data

- Ikonos: 07/22/2001
- 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

Tree Height, m

pdf

0.0
0.1
0.2
0.3
0.4

0
10
20
30
40
50
60

2003, ave ht = 9.62 m
2009, ave ht = 10.64 m

LIDAR, Oak Savanna, Ione, CA

Crown Diameter, m

pdf

0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18

2003: 8.06 m
2009: 8.79 m
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!
Seasonality of Soil Moisture

Oak Savanna 2005

Soil Moisture (cm^3/cm^3)

Day

Soil Moisture: 0-15 cm, 15-30 cm, 30-45 cm, 45-60 cm

Day Range: 0 to 400

Soil Moisture Graph
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

Ione, CA

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
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

Ione, CA

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\(^{-1}\)

Ione, CA

End of Hydrological Year

Water Flux (mm/y)

savanna
grassland
precipitation

End of Hydrological Year
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 Downregulates 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

Savanna vs Grassland

- GPP; r^2 = 0.53
- Reco; r^2 = 0.72
- Plot 1 Regr
Years that Promote Productivity, relative to the Prior year
Come at the Cost of More Respiration,
And Vice Versa

Year to Year Changes in Productivity

Coefficients:
\[ b[0] = 18.51 \]
\[ b[1] = 0.658 \]
\[ r \leq 0.727 \]
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

Quercus douglasii Range

Field Sites, near lone