Carbon & Water Exchange of an Oak-Grass Savanna Ecosystem

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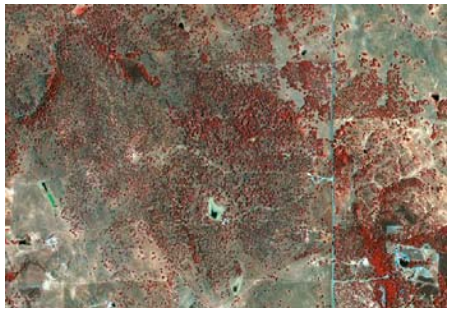


Oak-Grass Savanna: A Two Layer System

Winter:
Trees deciduous; grass green

Spring:
Trees green;grass green

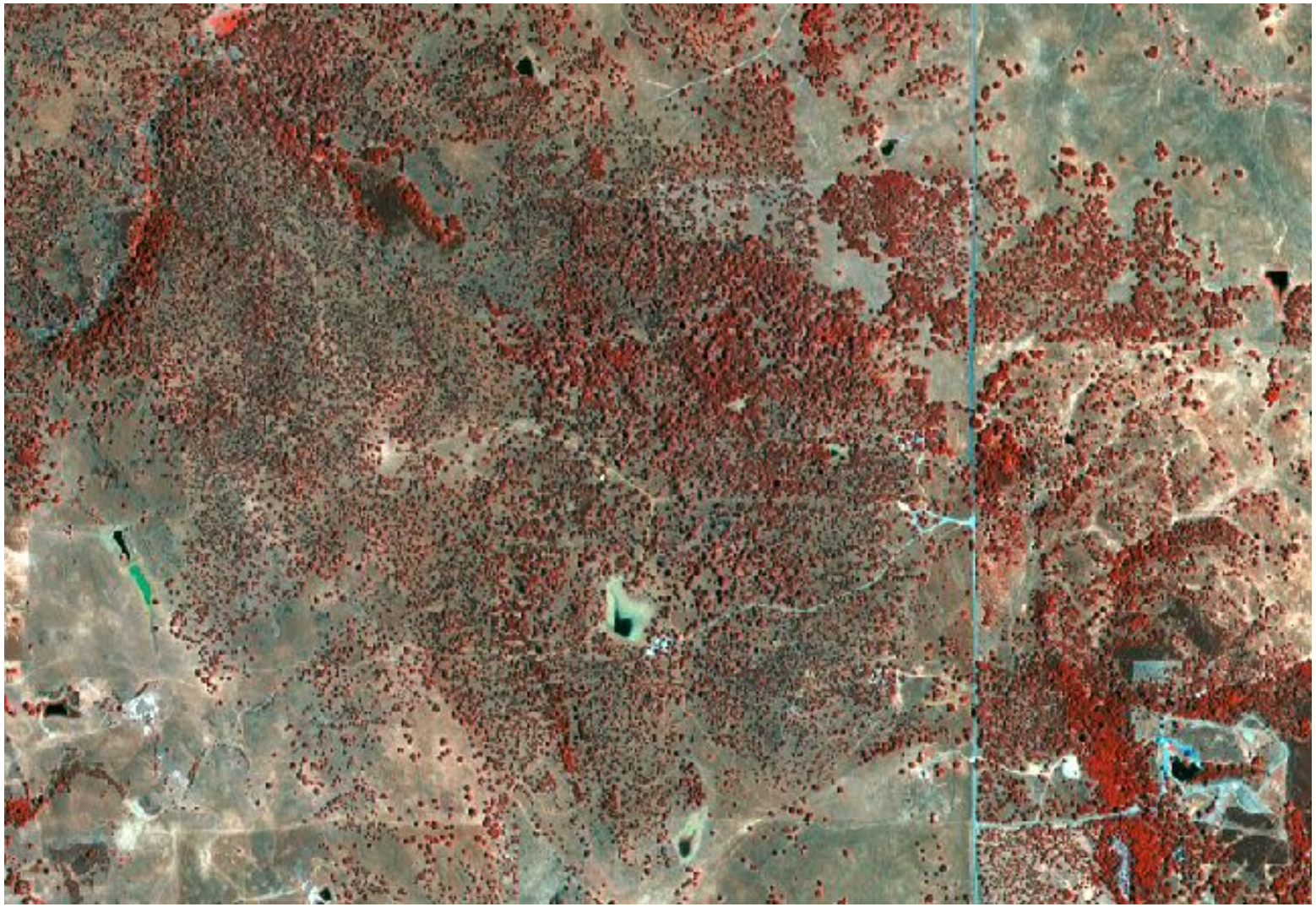
Summer:
Trees green; grass dead

Oak-Savanna Model System for Studying Ecosystem Ecology

- Structure/Function
  - Oak and grasses provide contrasting life forms, woody/herbaceous, perennial/annual
  - The Canopy is open and heterogeneous, giving us a opportunity to test the applicability of ecosystem and biogeophysical models, mostly developed for ideal and closed canopies
- Environmental Biology
  - The Mediterranean climate provides distinct wet/ cool and dry/hot seasons to examine the ecosystem response (photosynthesis, transpiration, respiration, stomatal conductance) to a spectrum of soil moisture and temperature conditions
- Global Change
  - The Mediterranean climate experiences great extremes in inter-annual variability in rainfall; we experience a wider range in precipitation over a few years than long-term predicted changes.

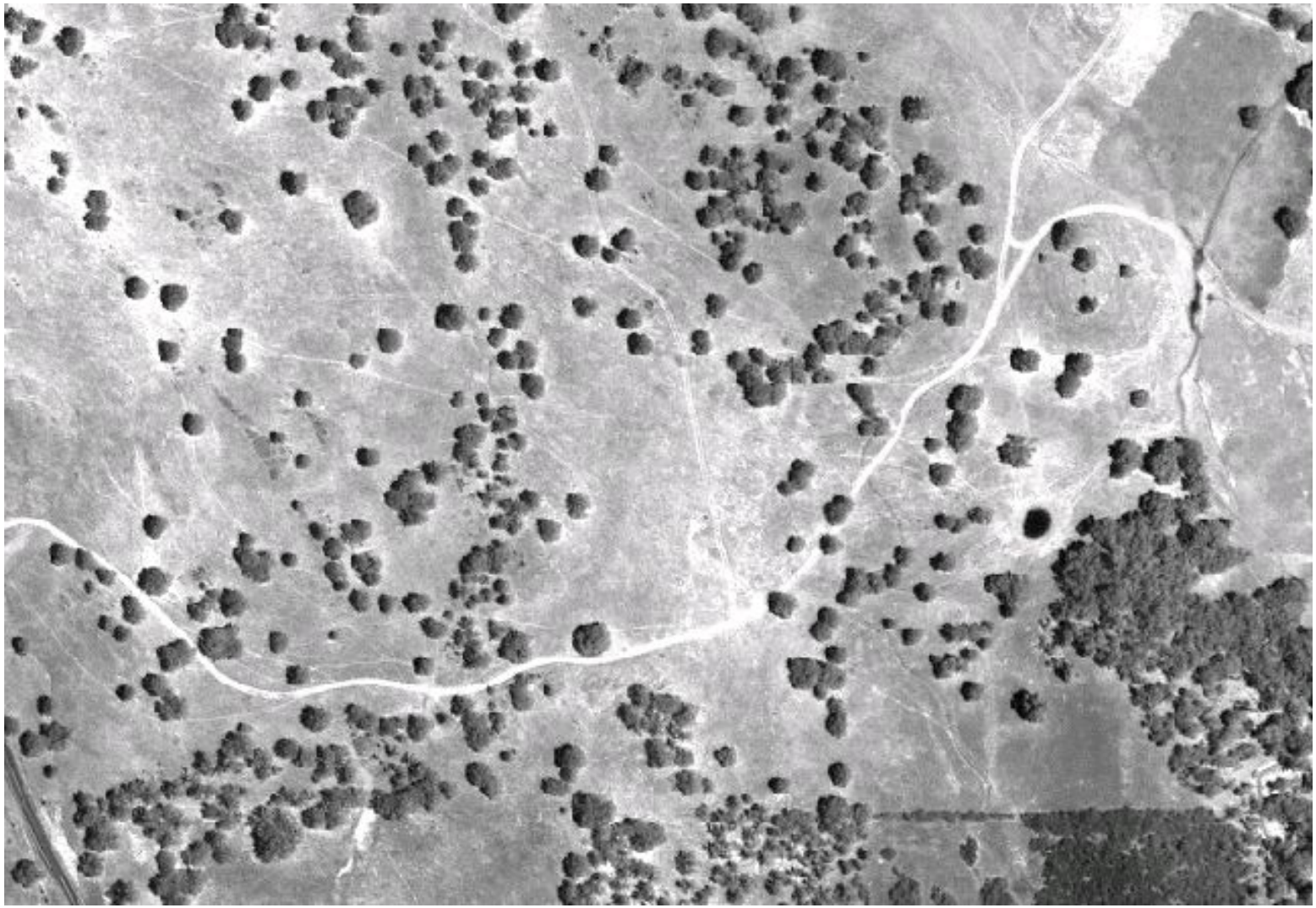
Tonzi Ranch Flux Tower

IKONOS: Savanna & Fetch



Vaira Ranch

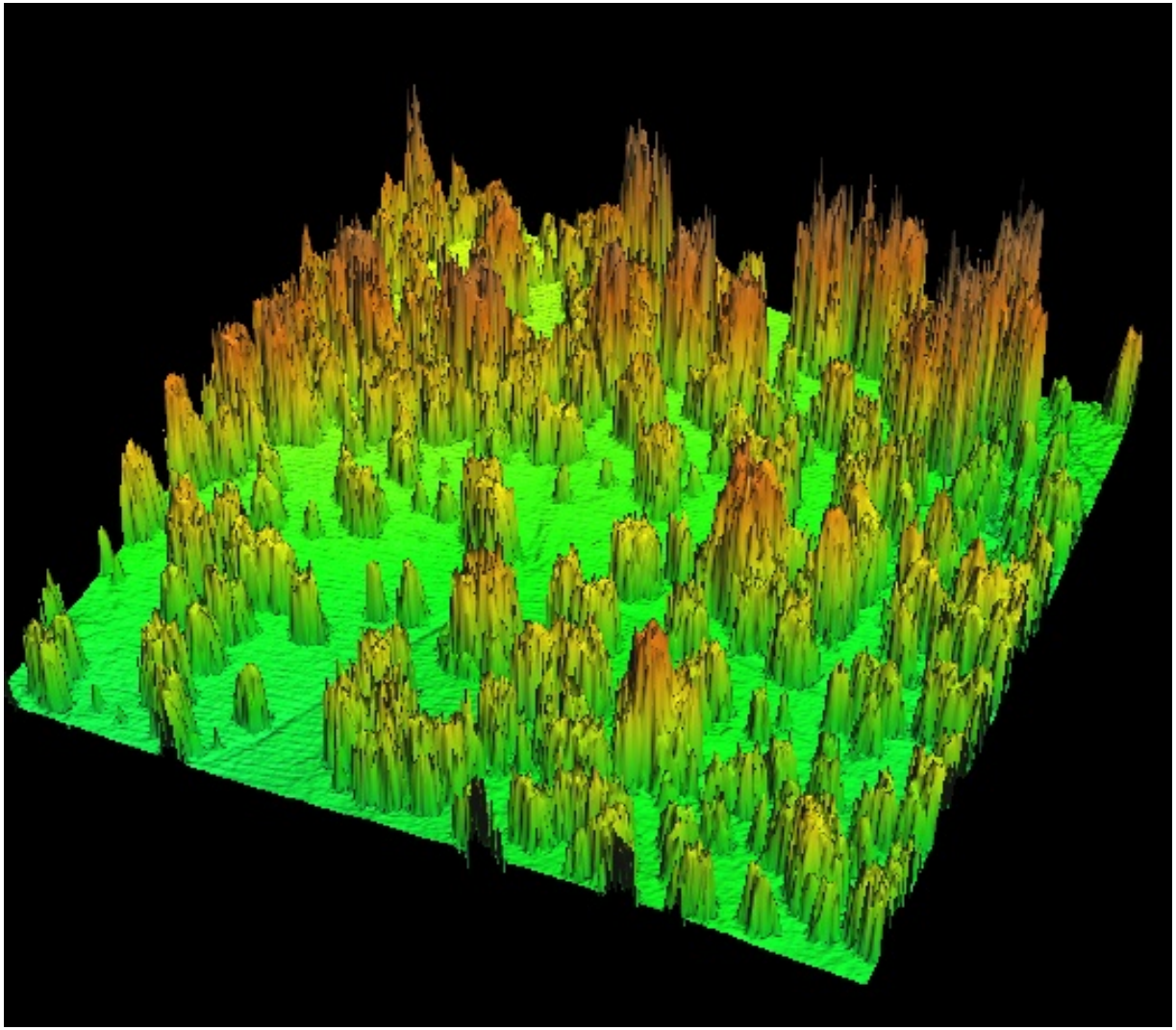
IKONOS:Grassland



Canopy Structure: Tonzi Ranch

- Blue oak (*Quercus douglasii*)
- LAI=0.90
- Height 7.1 +/- 3.05 m
- Diameter at breast height 26.6 +/- 0.11 cm
- Understory: annual C_3 grasses
  - *Brachypodium distachyon, Hypochaeris glabra, Bromus madritensis*

Canopy Structure:
Laser Altimeter Data

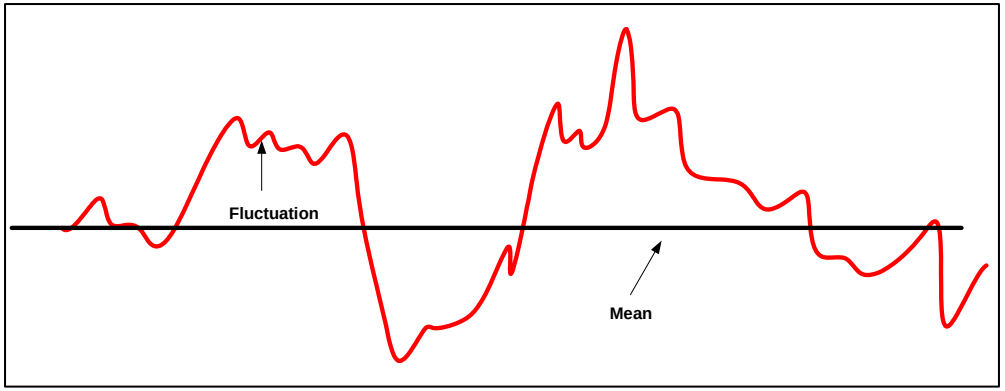


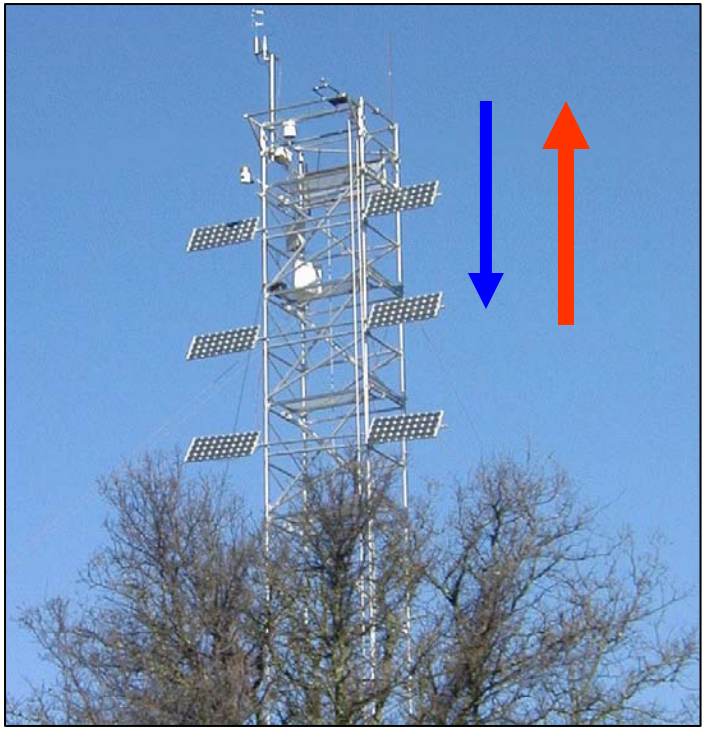
Experimental Methods

- Eddy Covariance
  - above the stand (20 m tower)
  - below the stand (2 m tower)
- Micrometeorology
- Sap flow (heat pulse)
- Soil respiration chambers
- Leaf Physiology (A-Ci curves)

Eddy Covariance

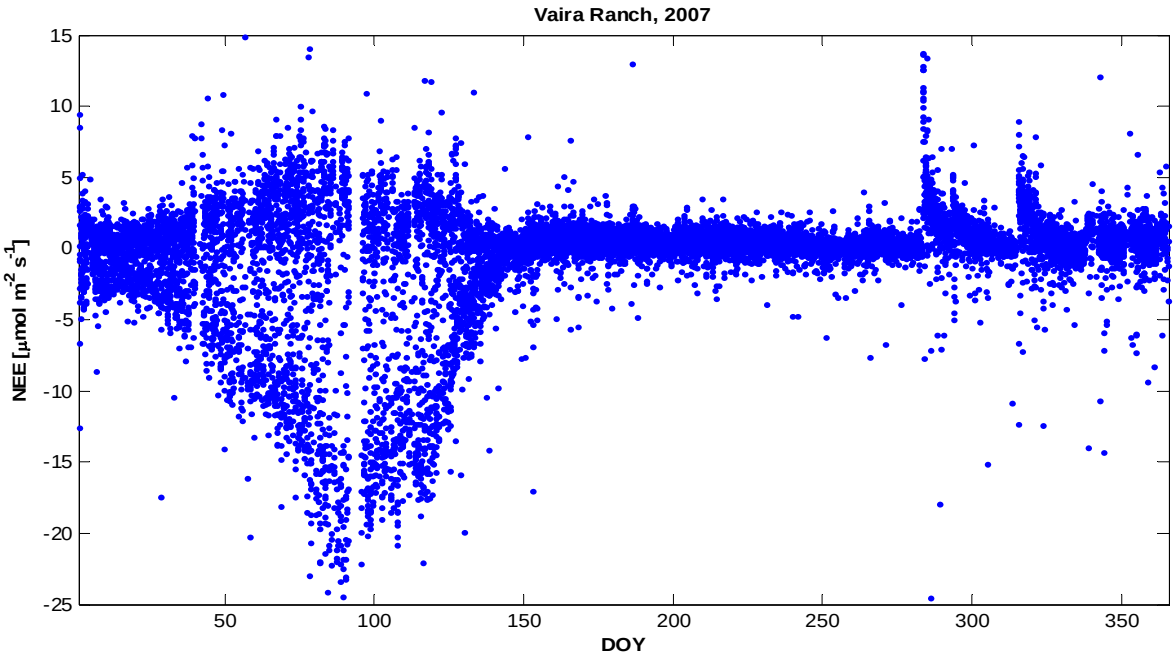
$$F = \overline{w'c'}$$

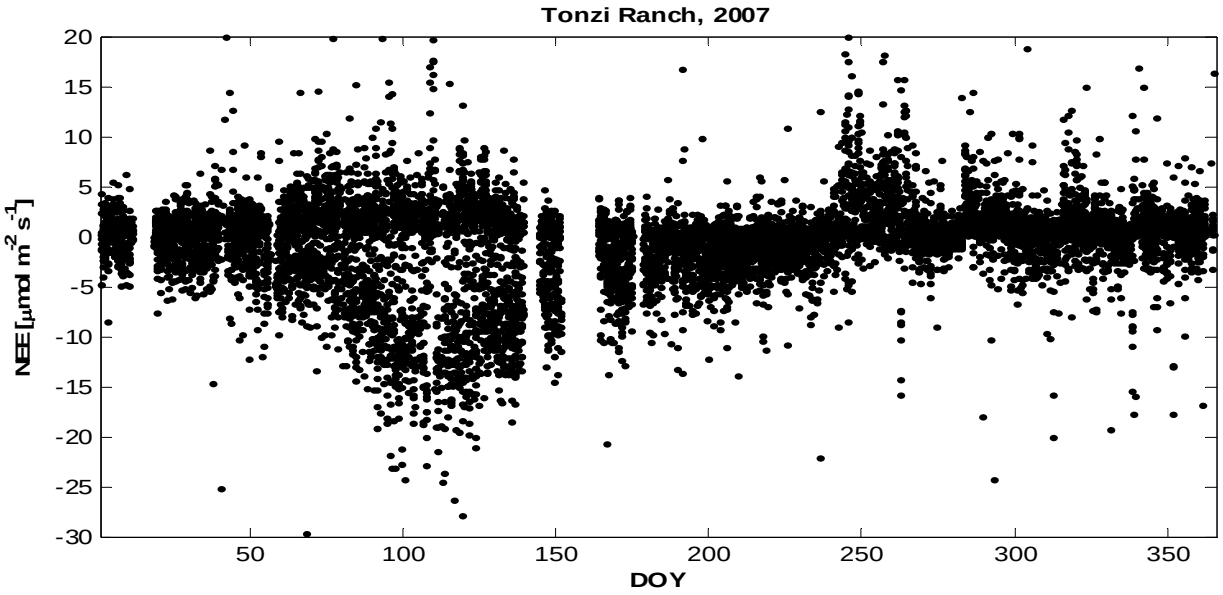




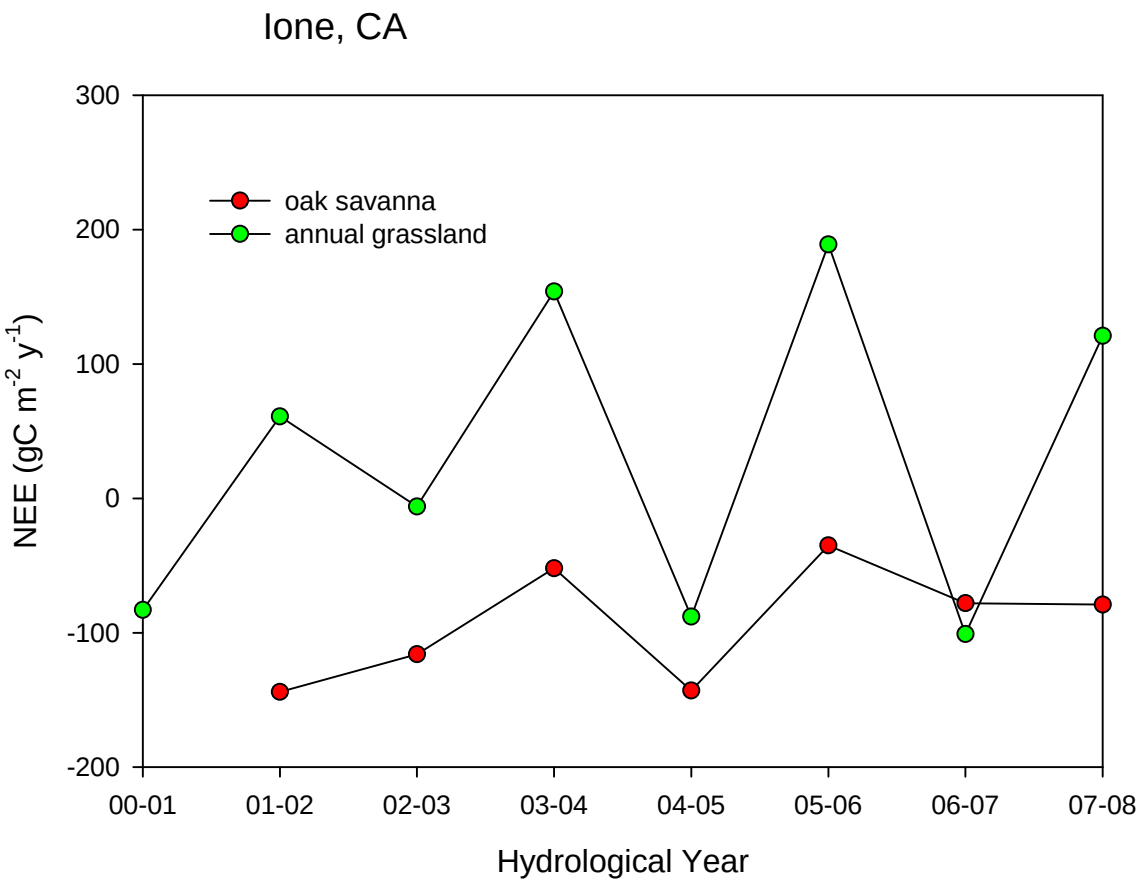
Ecosystem Ecology

‘Ecosystem Breathing’



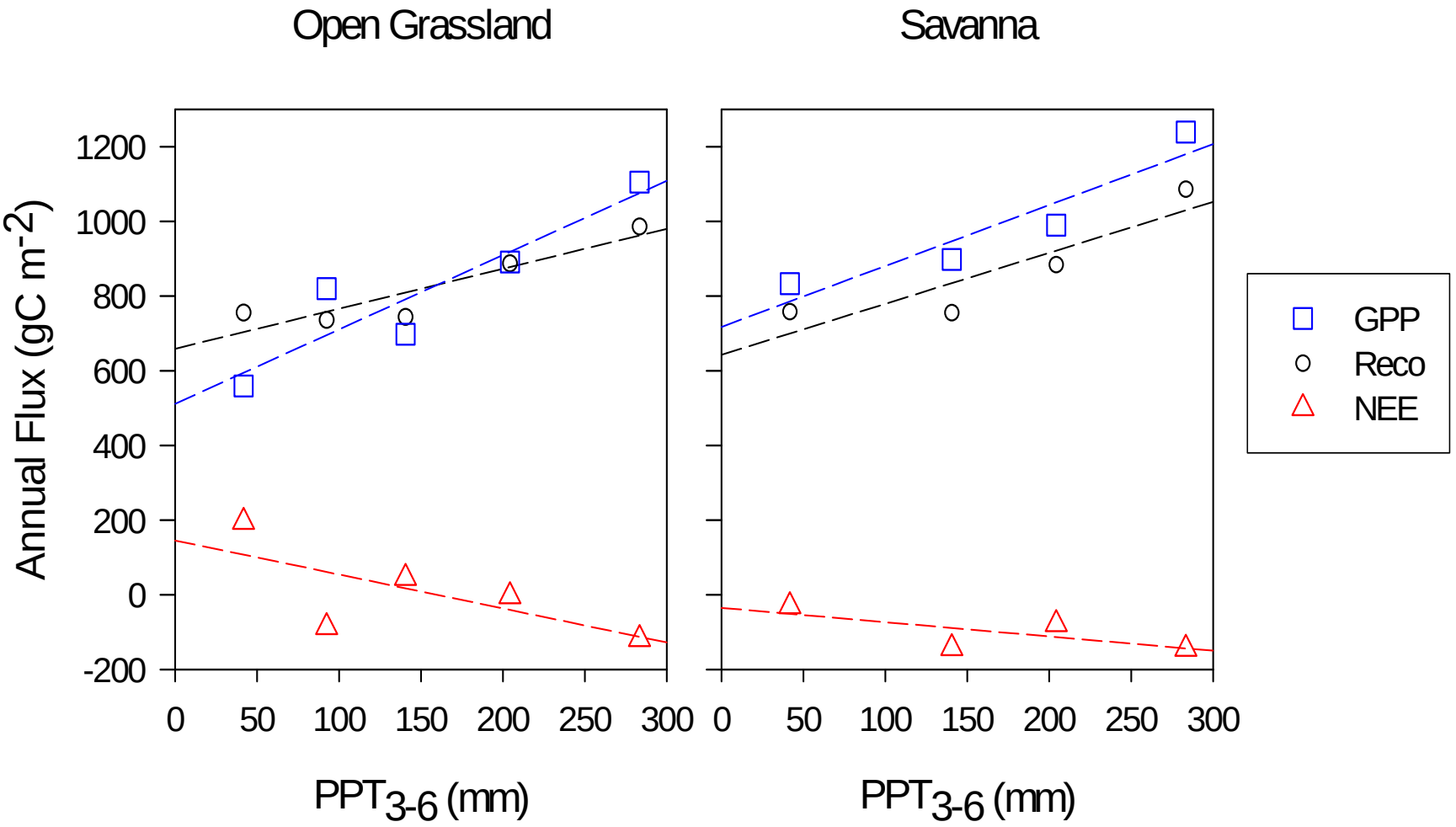


Oak Woodlands are Carbon Sinks, -92 +/- 43 gC m^{-2} y^{-1}
Annual Grasslands are Carbon Neutral, 30 +/- 116 gC m^{-2} y^{-1}



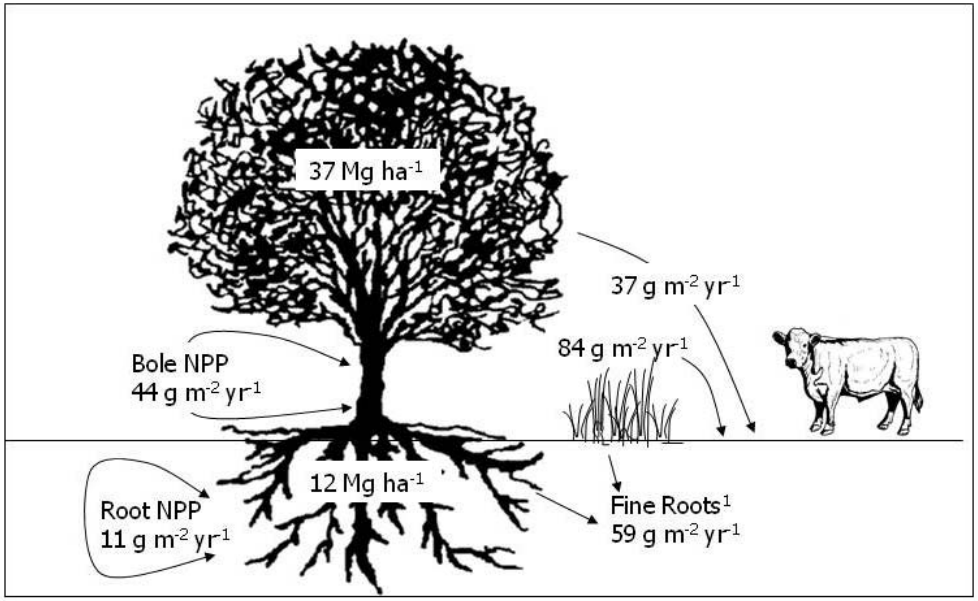
Oak Woodlands are Risk Adverse, they Experience less inter-annual variation in NEE than Grasslands

Carbon Fluxes Scale with Spring Rainfall



Ma et al, 2007 AgForMet

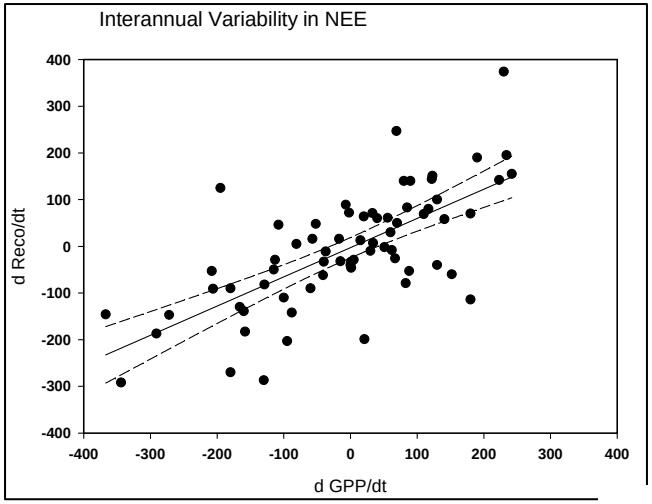
Net Primary Productivity



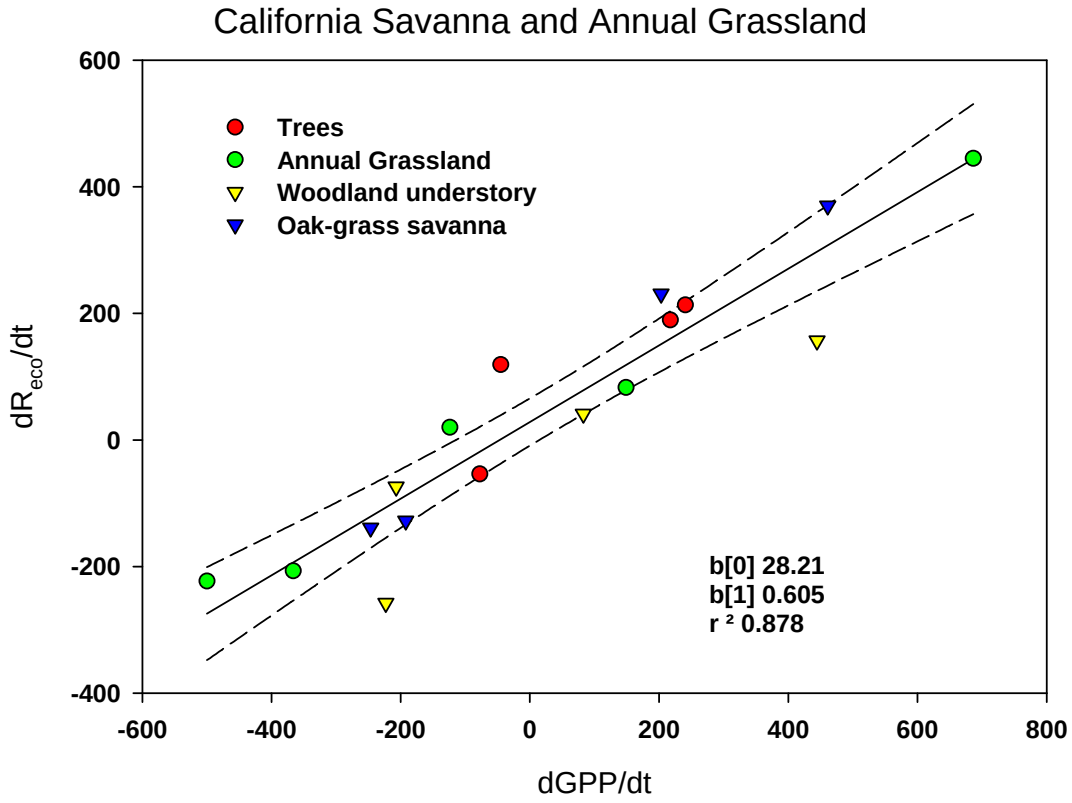
John Battle's biometric NPP = 235 gC m^{-2} y^{-1}.

NPP = GPPtree - Ra_tree - Rh = 299 gC m^{-2} y^{-1}

NPP=NEP+Rh=97+186=283 gC m^{-2} y^{-1}.



Interannual Variability in GPP and Reco scale with one another

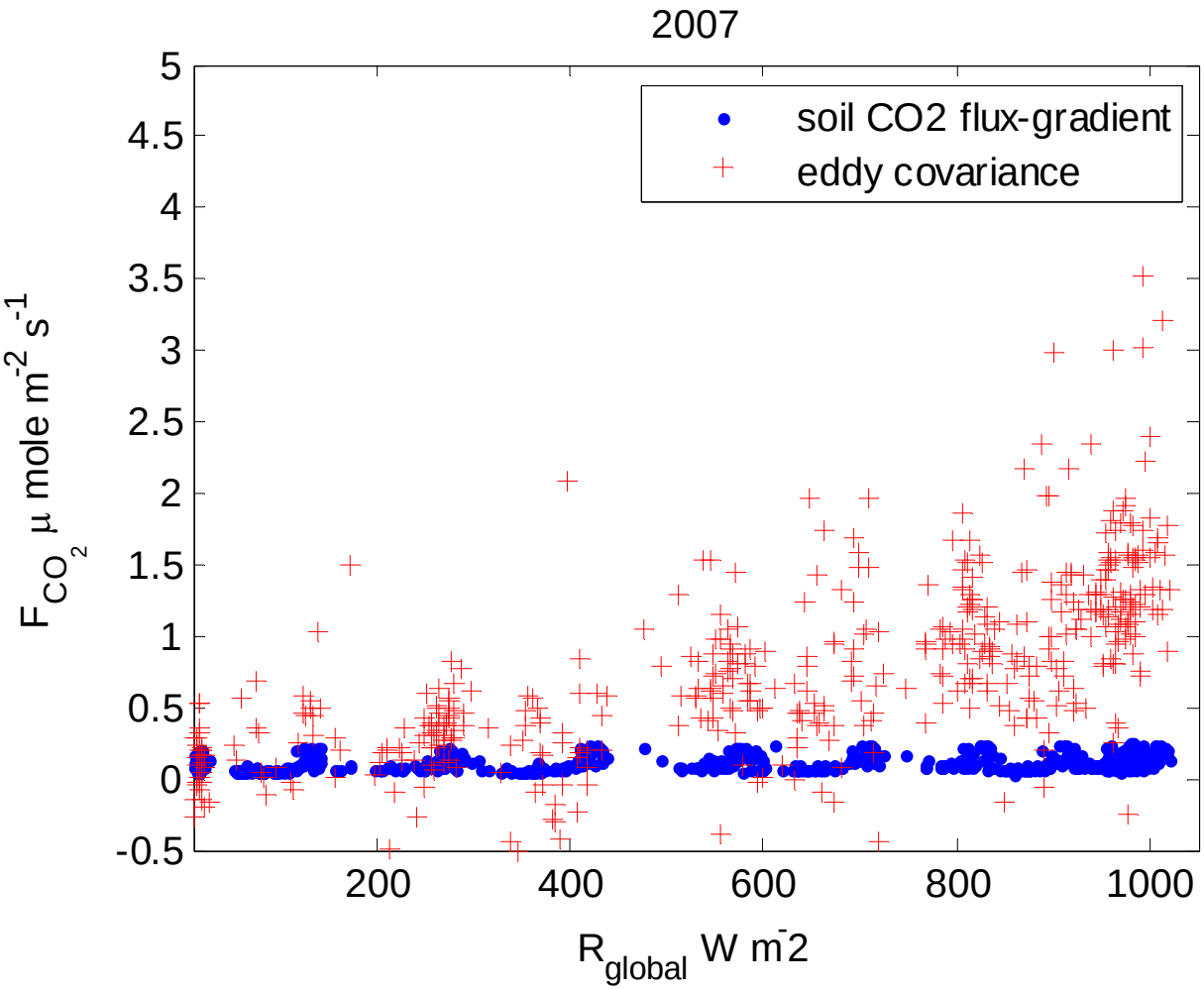


What Happens to the Grass?

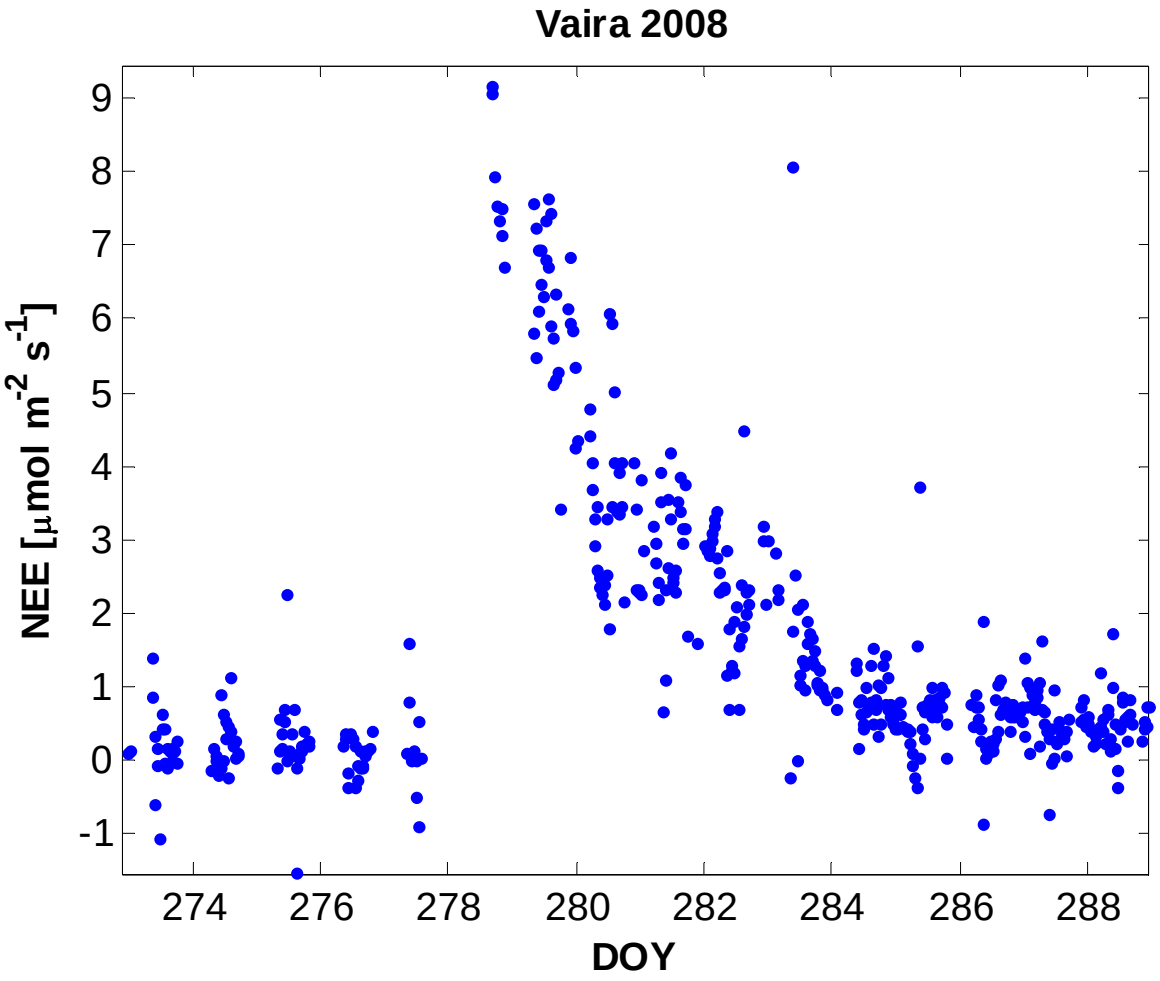
June

October

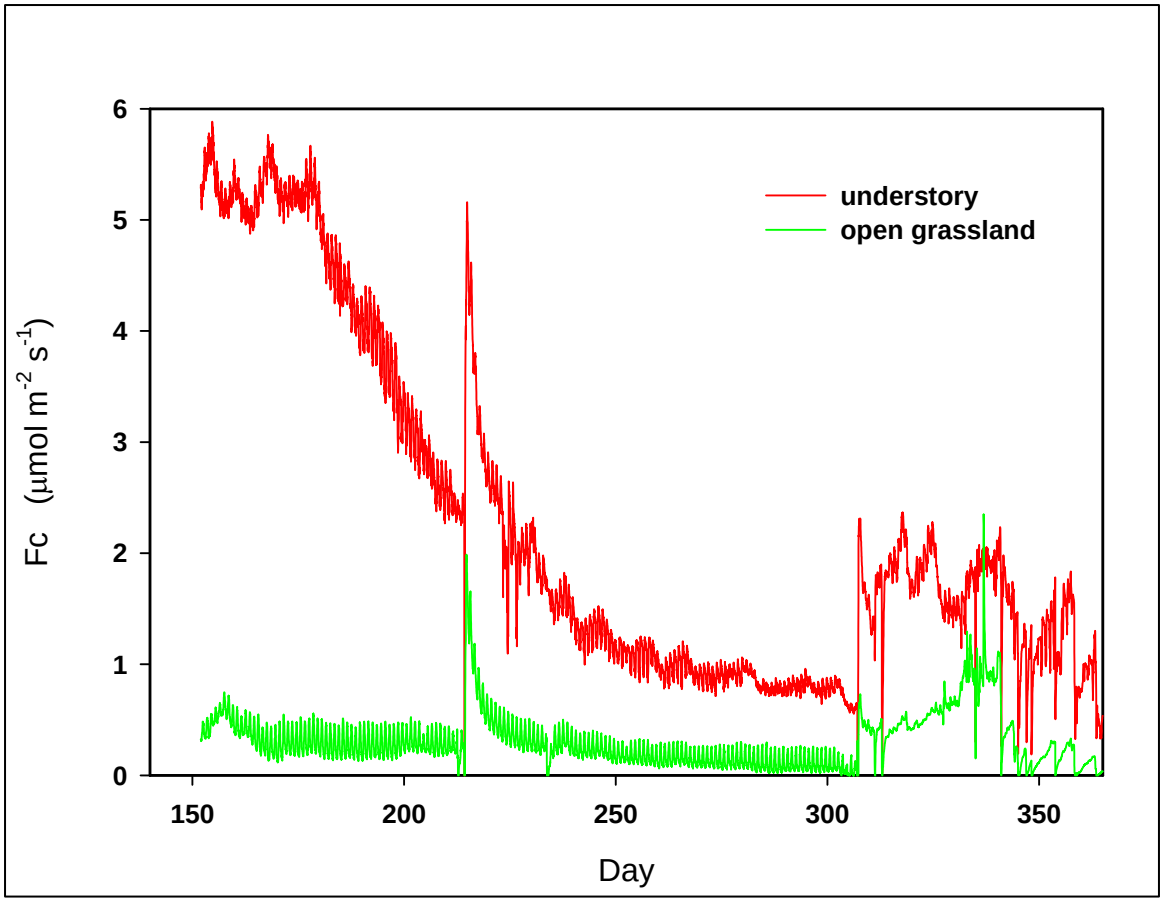
PhotoDegradation Can Be a Important Pathway for Carbon Loss in Semi-Arid Rangelands (~20-30 gC m^{-2} $season^{-1}$)



Sustained and Elevated Respiration after Fall Rain

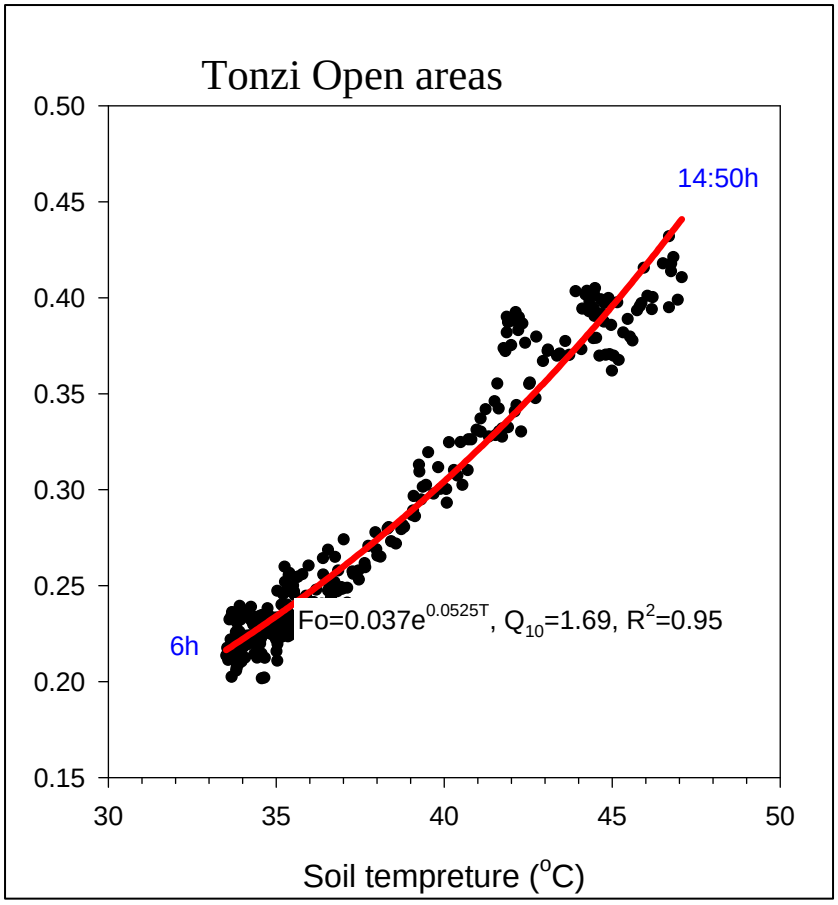


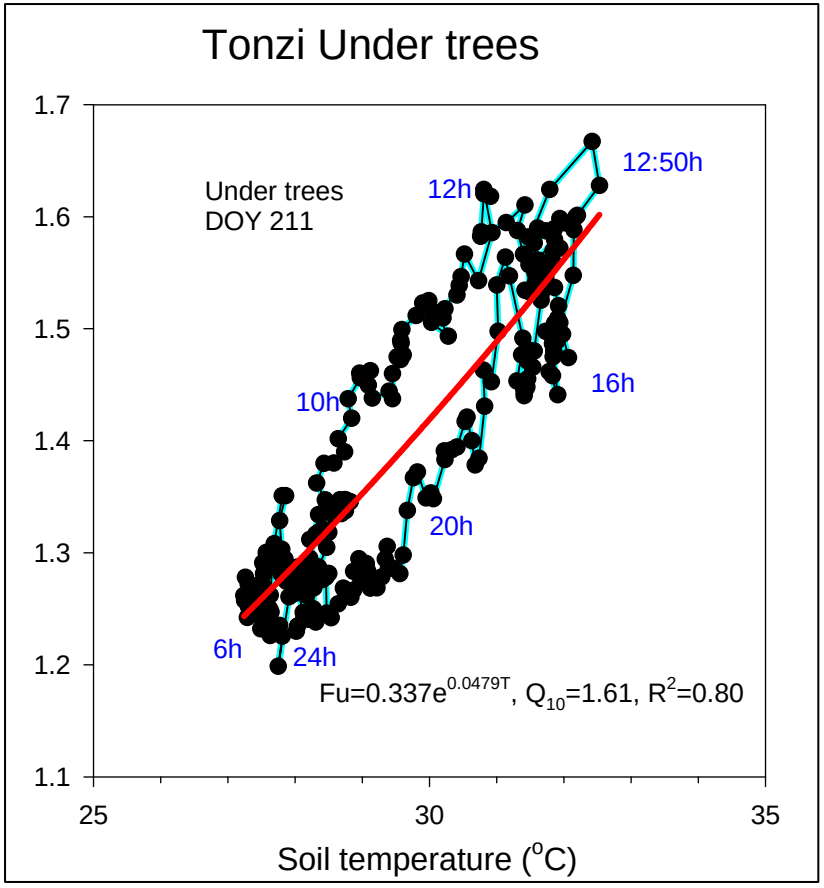
Impacts of Photosynthesis and rain pulse on ecosystem respiration of the Oak Woodland



Baldocchi et al, JGR, Biogeosciences, 2006

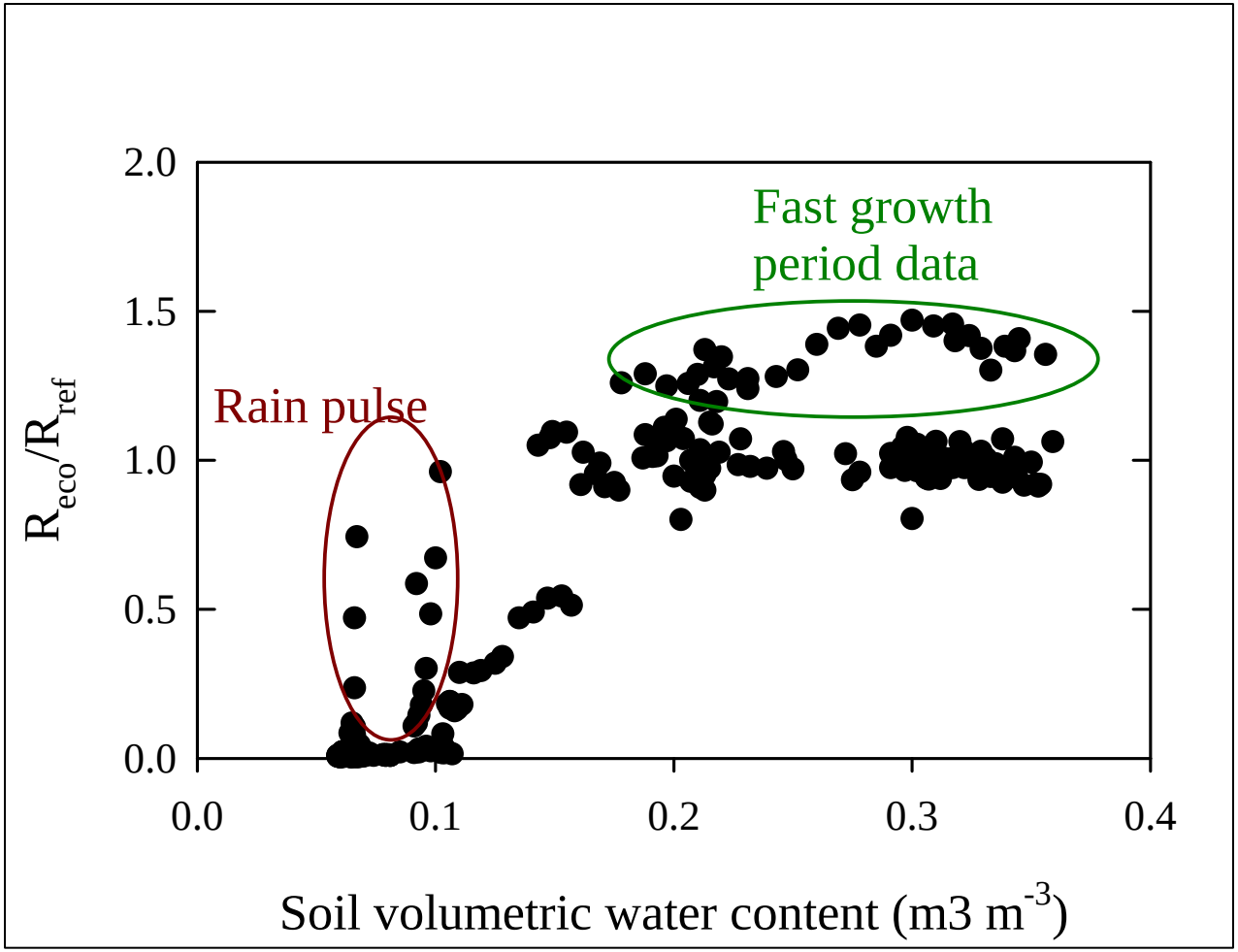
Respiration and Photosynthesis





Tang, Baldocchi, Xu, Global Change Biology, 2005

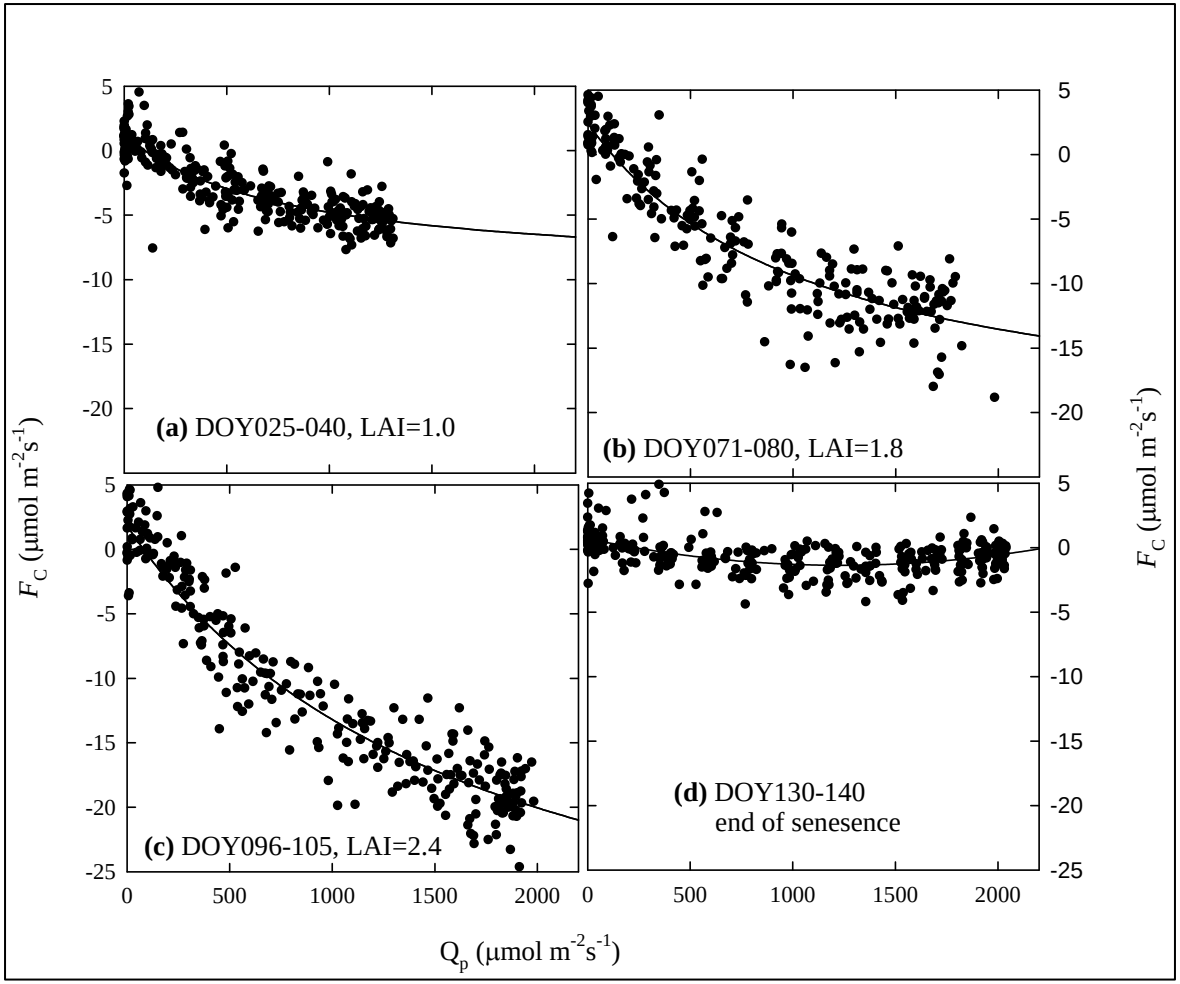
Controls on Ecosystem Respiration of the Grassland:
Soil Moisture, Phenology (reproduction), Temperature and Rain Pulses



Xu + Baldocchi, AgForMet 2004

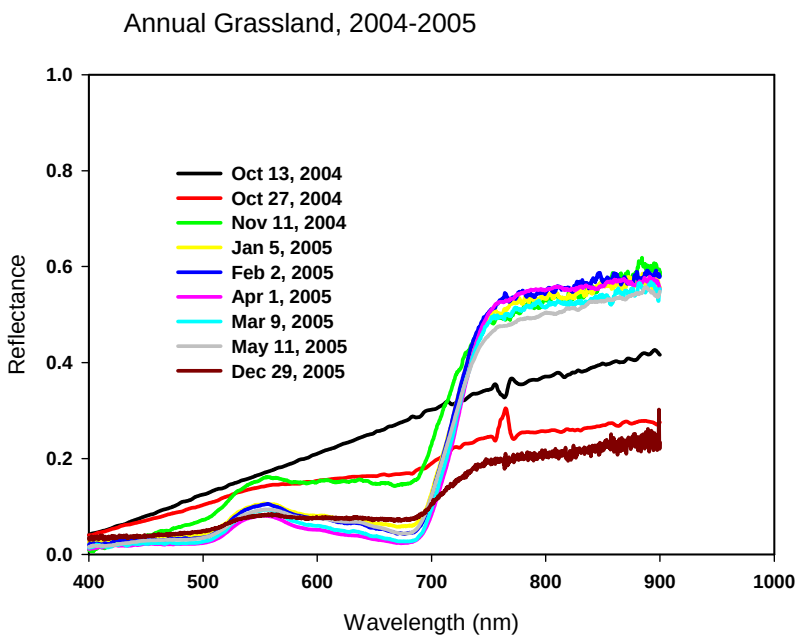
Remote Sensing of Canopy Structure and NPP

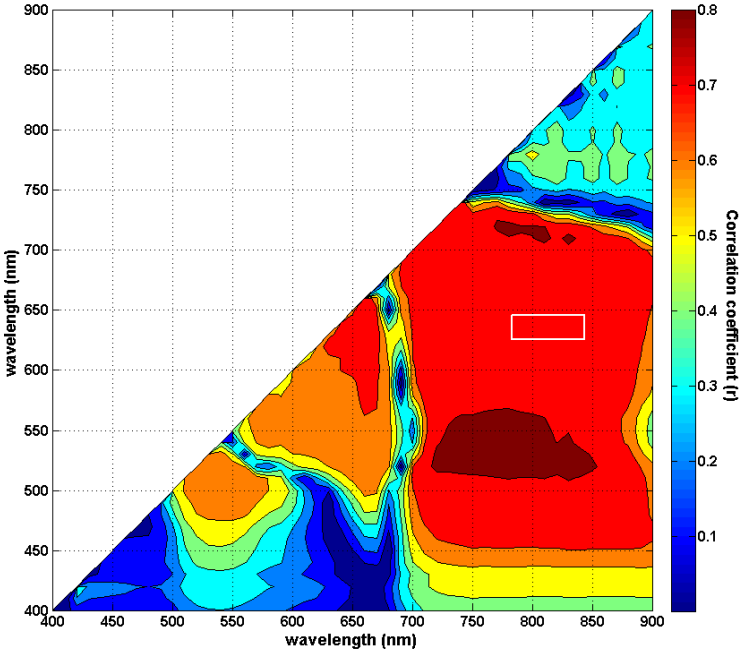
Grassland CO_2 flux vs Sunlight at different LAI



Xu + Baldocchi, AgForMet 2004

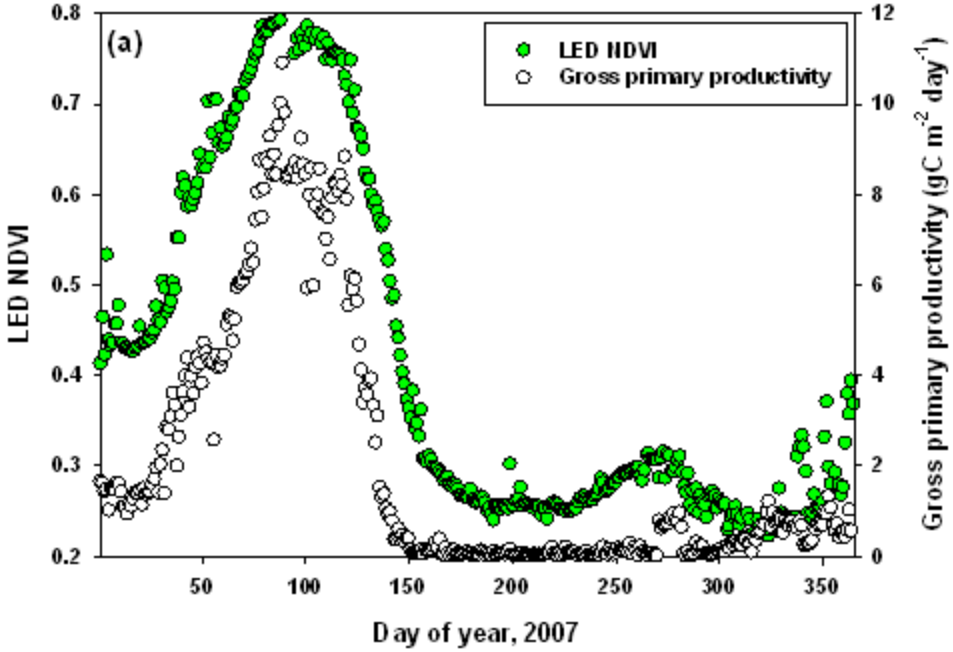
Refining Spectral Vegetation Indices for Remote Sensing of Fluxes from Space

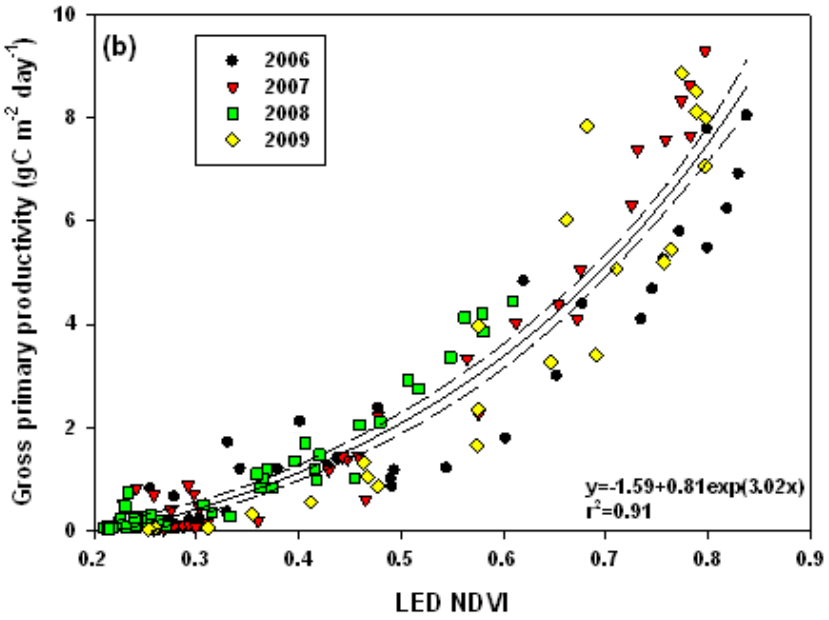




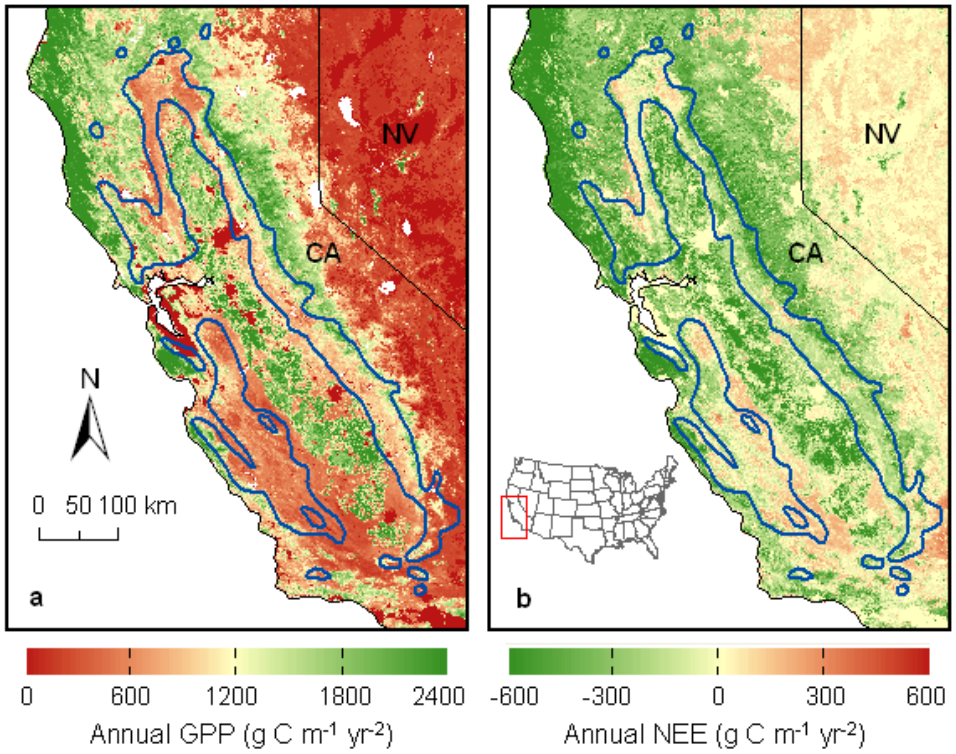
Ryu, Ma, Falk, Sonnentag, Baldocchi, submitted Frontiers of Ecology

Remote Sensing and Ecosystem Metabolism





Upscale GPP and NEE to the Biome Scale



area-averaged fluxes of *NEE* and *GPP* were -150 and 932 gC m^{-2} y^{-1}

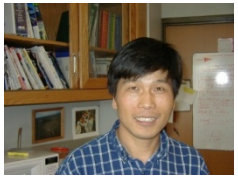
net and gross carbon fluxes equal -8.6 and 53.8 TgC y^{-1}

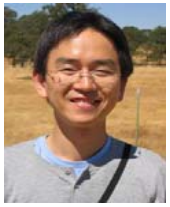
Jingfeng Xiao and D Baldocchi

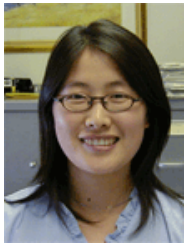
Conclusions

- Oak Woodlands are Carbon Sinks, Grasslands are Carbon Neutral
- Year to year variability in Carbon Uptake is due to length of wet season.
  - Oaks are risk adverse and experience less inter-annual variability in NEE than grasslands
- Photosynthesis and Respiration are tightly linked
  - Oaks need high N levels to attain sufficient rates of carbon assimilation for the short growing season
- Savanna woodlands need about 80 mm more water to function than nearby grasslands
  - Trees tap ground-water to sustain themselves during the summer
- Oaks are darker and warmer than grasslands

Biometeorology Team

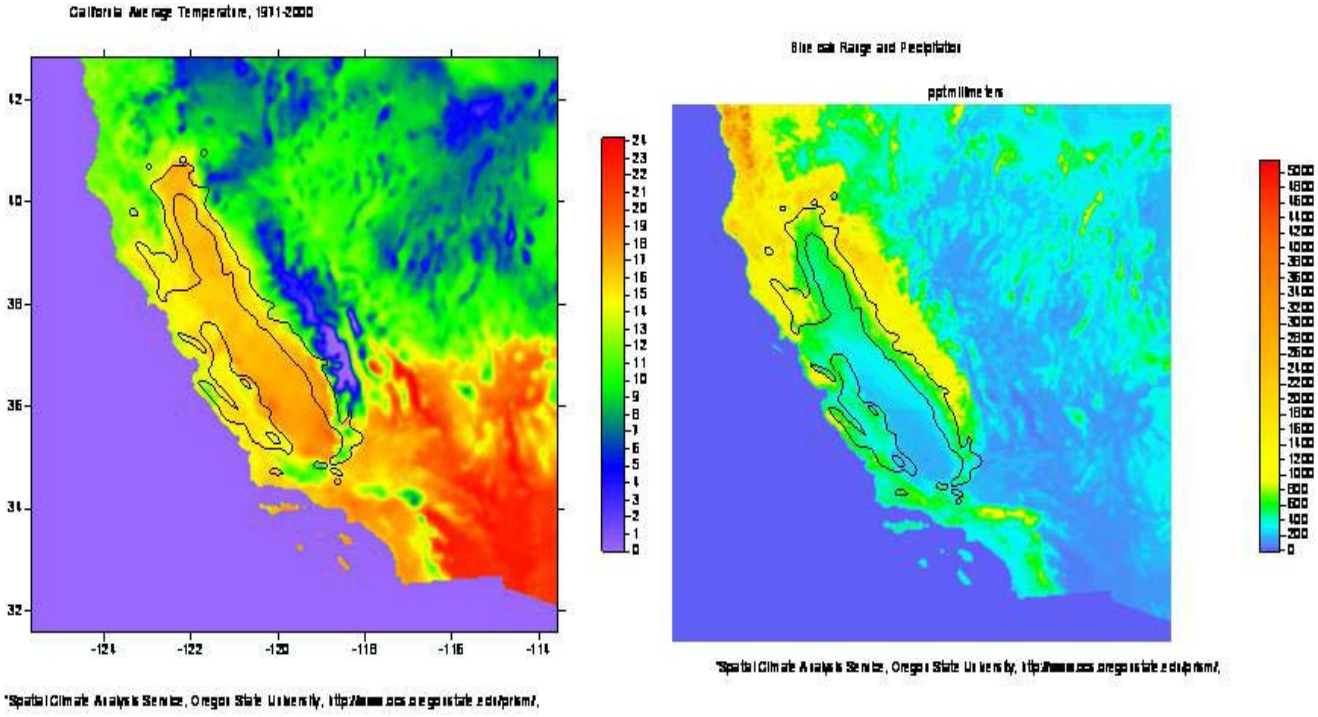






Funding: US DOE/TCP;
WESTGEC; Kearney; Ca Ag Expt Station

Annual Precipitation ~500 - 700 mm/y
Mean Annual Temperature ~ 14-16 C



*Spatial Climate Analysis Service, Oregon State University, http://www.ocs.oregonstate.edu/prism/,

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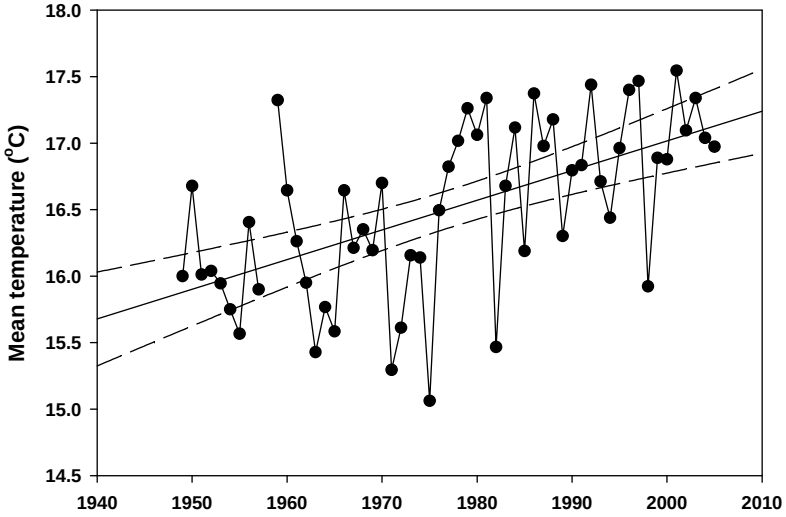
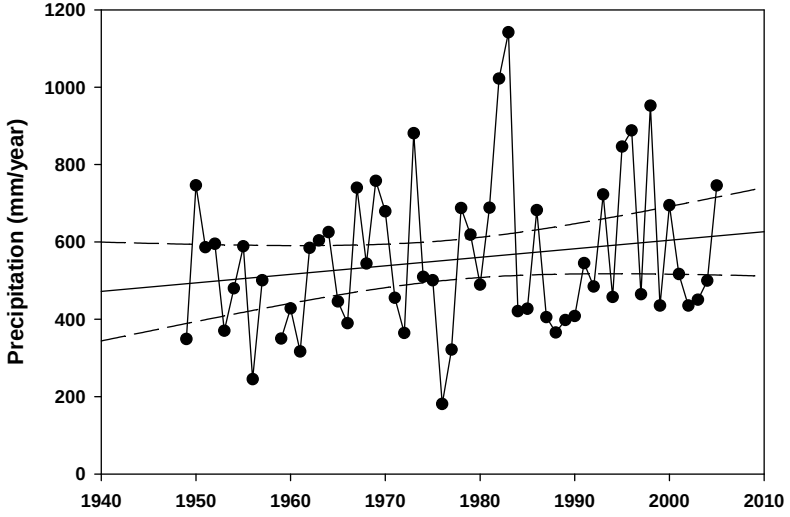
Climate Trends: Pardee, CA

Temperature Increased by about 1.25 C over 50 Years;
Precipitation Trend is Flat, but with High Inter-annual Variation