

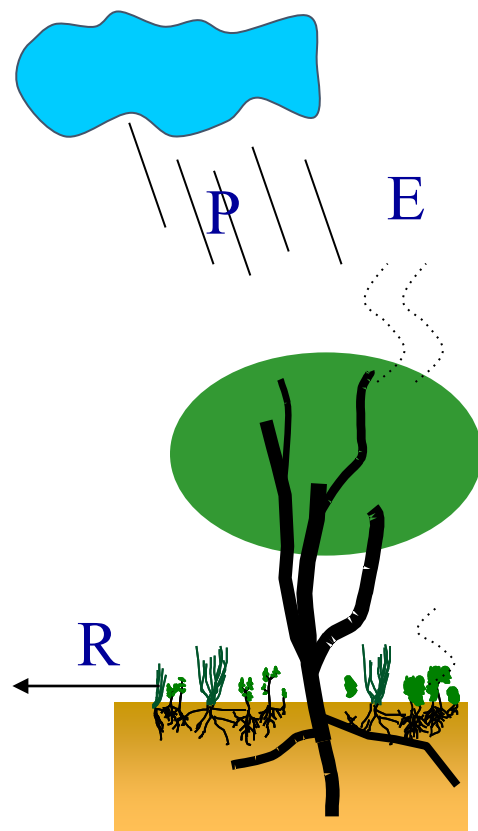
# **Two decades of riparian woodland water vapor and carbon dioxide flux responses to environmental variability**

**Presentation for the USPP  
Tech Committee  
April 14, 2024**

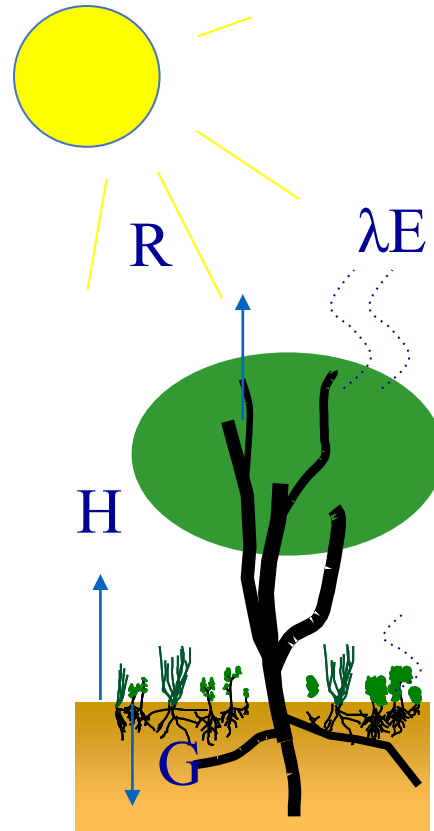


**Erika Gallo, Russell Scott (USDA-ARS)**

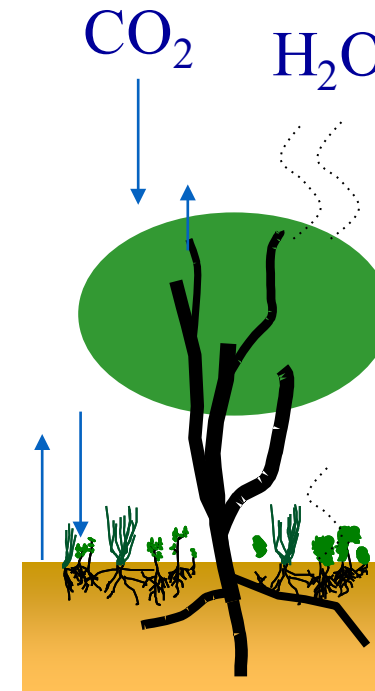
# The breathing of the biosphere using flux towers/eddy covariance



Water



Energy



Carbon dioxide

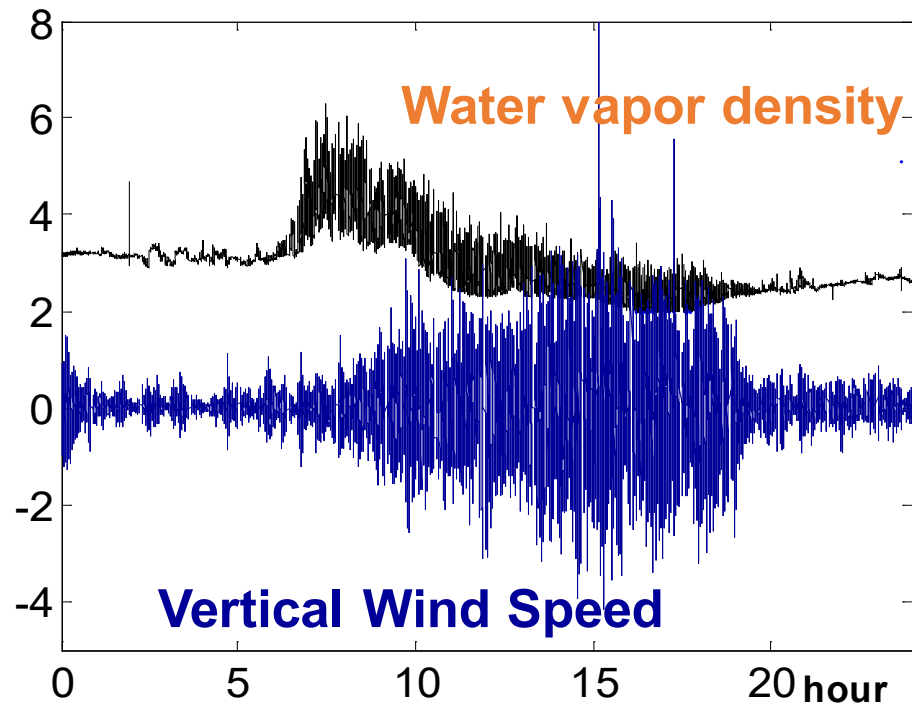
Net ecosystem  
production of CO<sub>2</sub>  
NEP = GEP - Reco

# How do we quantify energy and mass exchange at ecosystem scale?



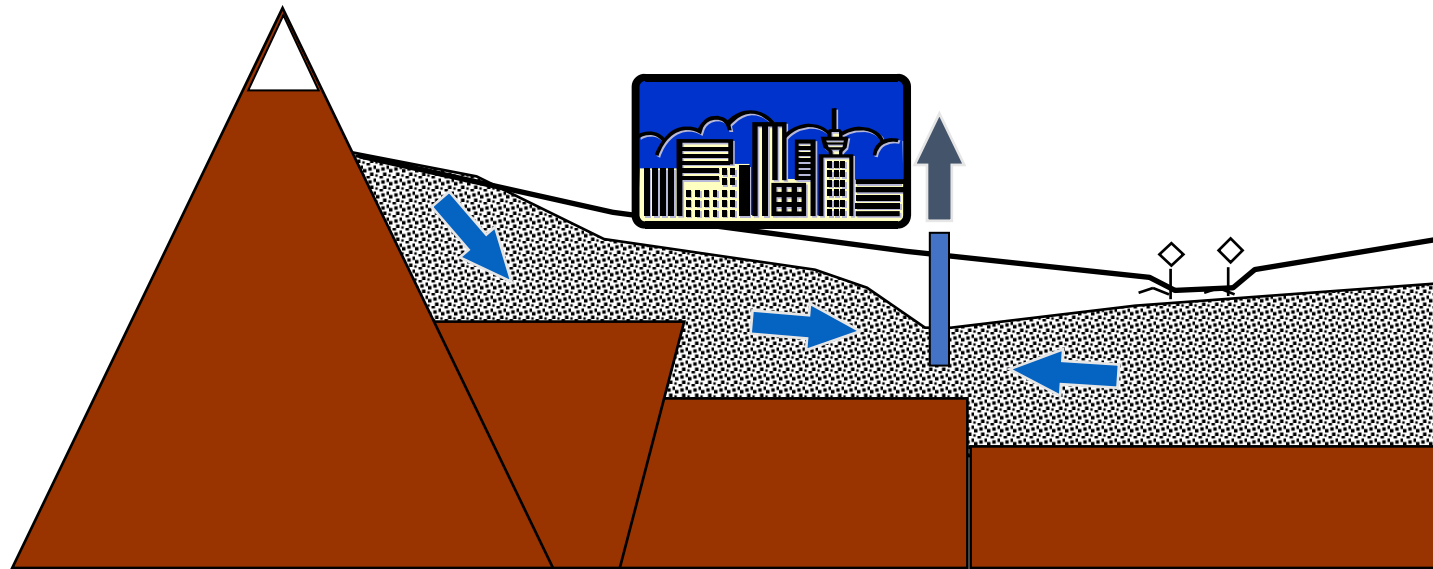
These eddies are largely responsible for moving things (e.g., energy, water vapor, carbon dioxide) between the biosphere and atmosphere

# Eddy Covariance Measurements: patch- or ecosystem-scale heat, water and carbon dioxide flux



Global network for ground-truthing satellite and global climate models

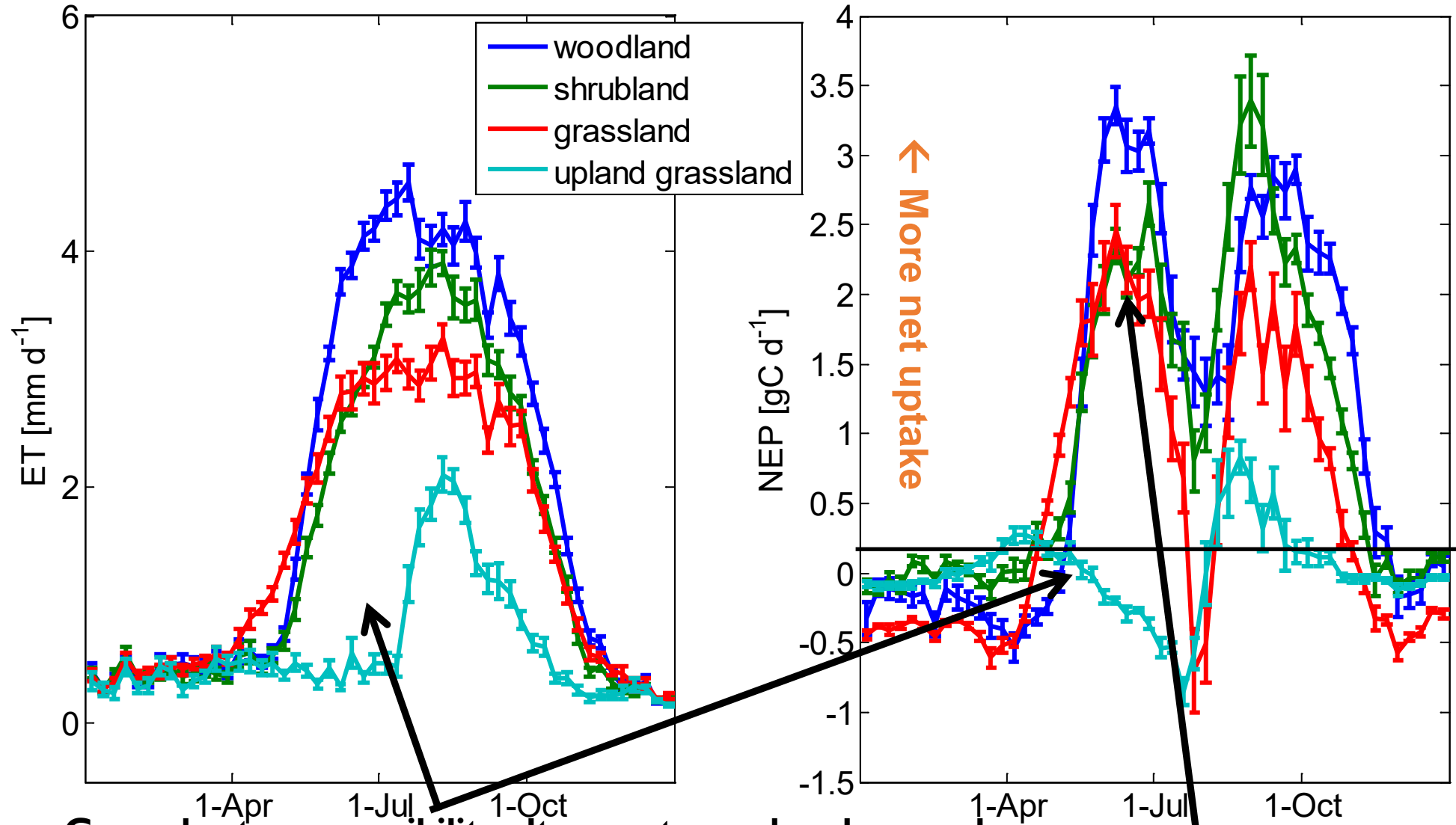
Why are we interested in riparian ecosystem functioning?



**Riparian ET is a major, yet often poorly quantified, component of a semi-arid basin's water budget**

**and riparian (i.e., groundwater dependent) ecosystems are unique and important ecosystems, particularly, in dryland regions**

# Groundwater dependent ecosystems are different



Groundwater accessibility alters water and carbon exchange

Woodland/Grassland net productivity peaks before summer rains







# Charleston mesquite woodland





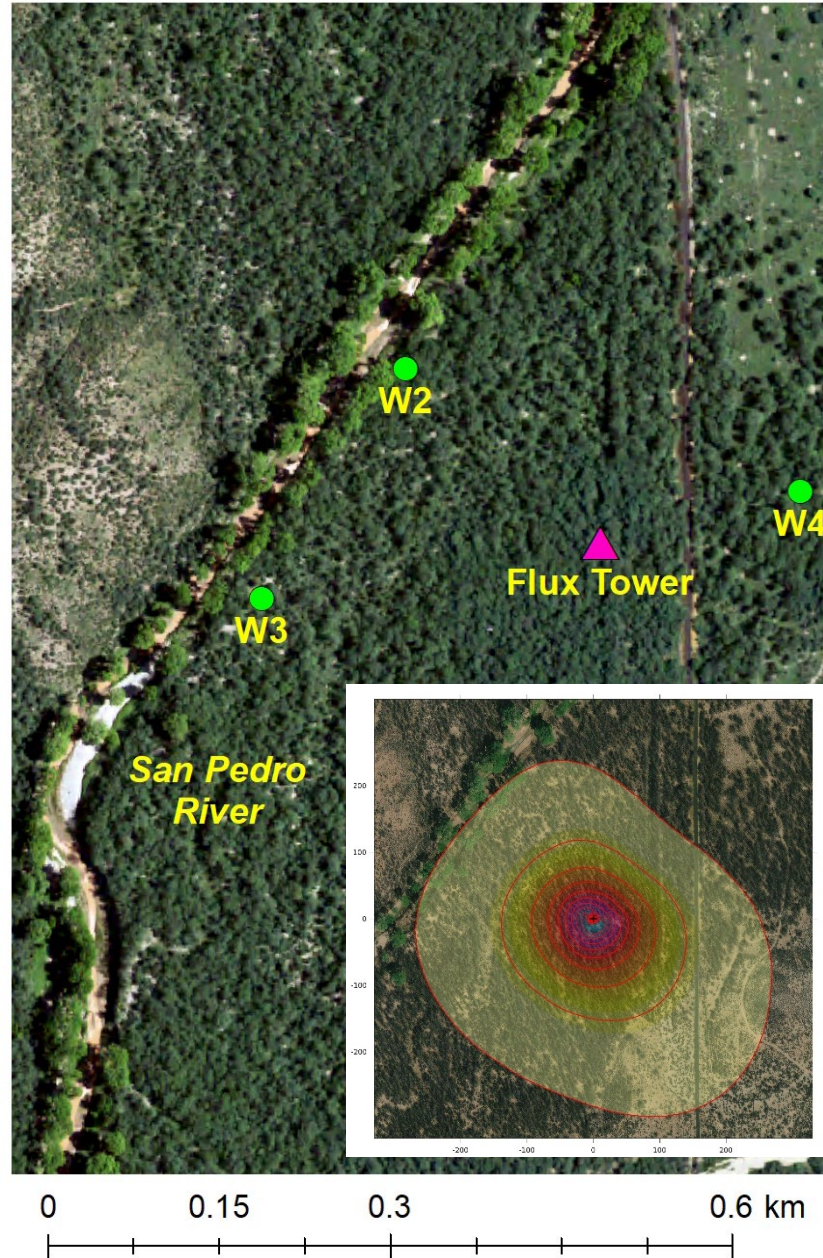
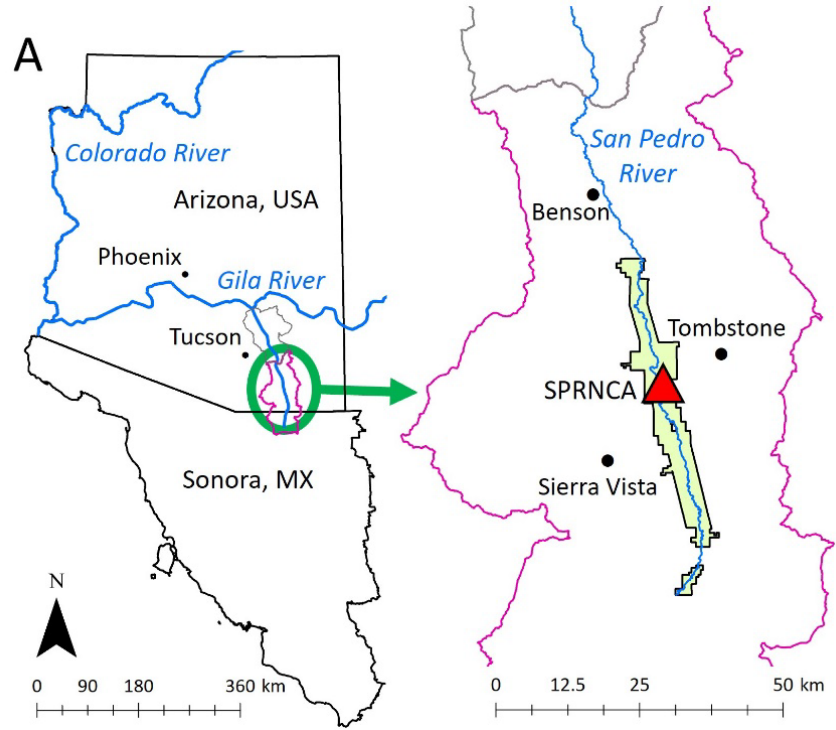
# 21 years of eddy covariance data!

## Questions -

- 1) How have meteorological conditions, water and C fluxes changed over the last two decades?
- 2) What drives the interannual variability of ET and C fluxes?



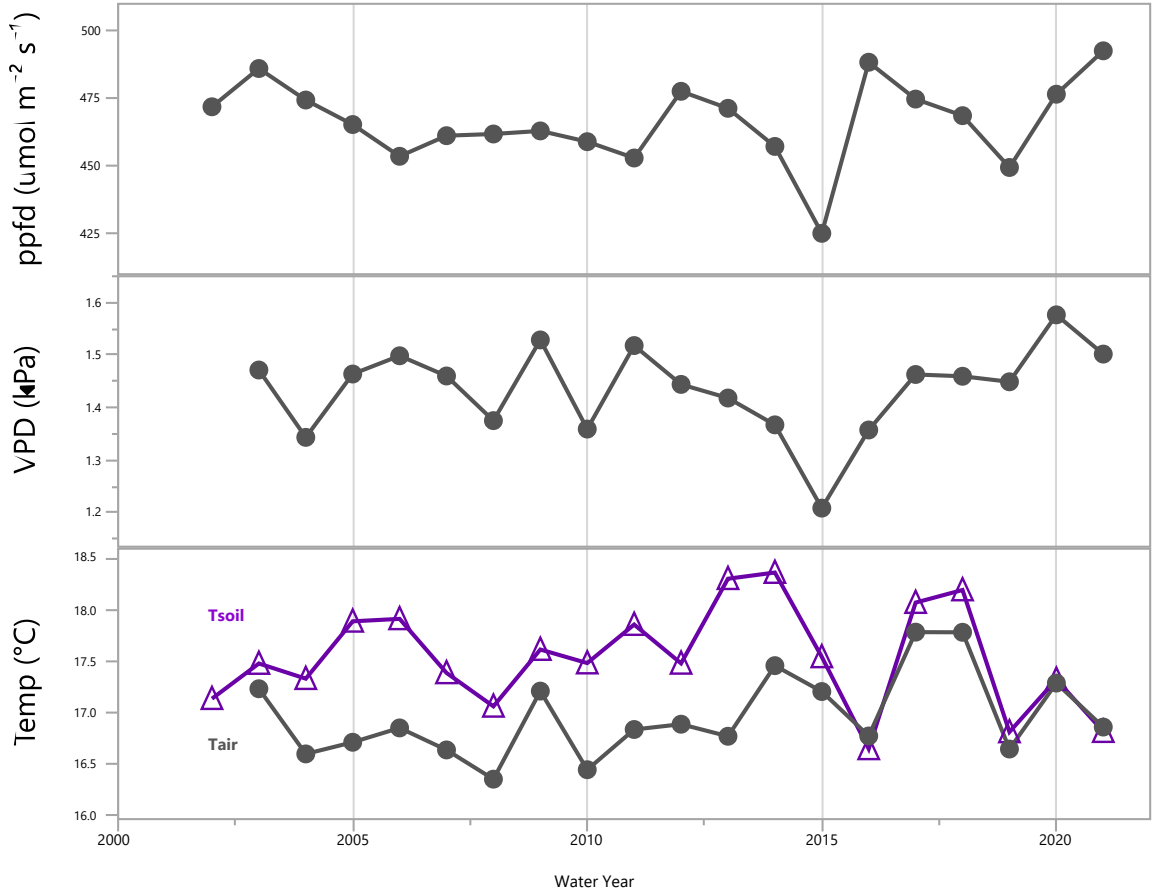
# Where and How?



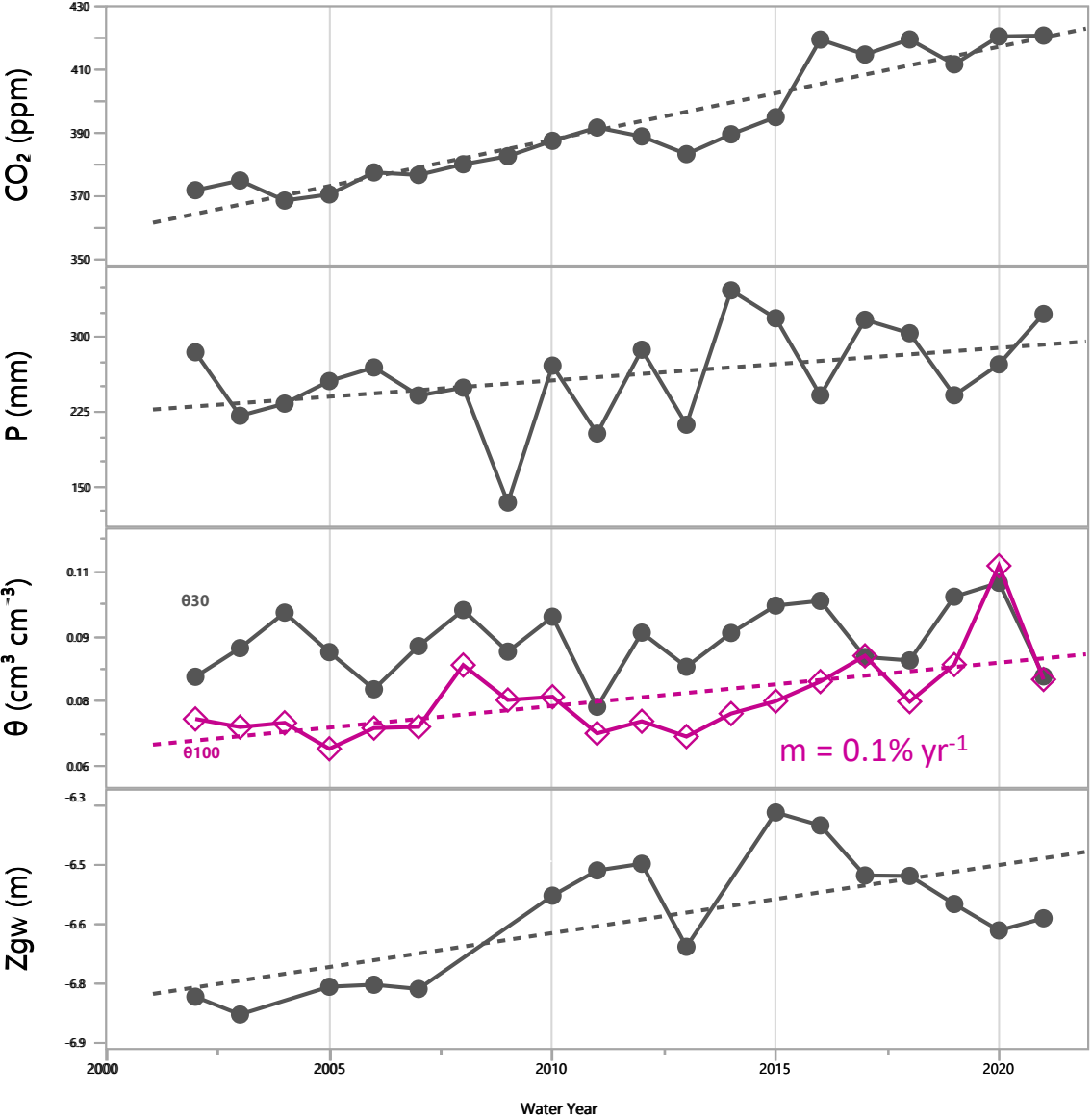


# Interannual variability: hydromet drivers

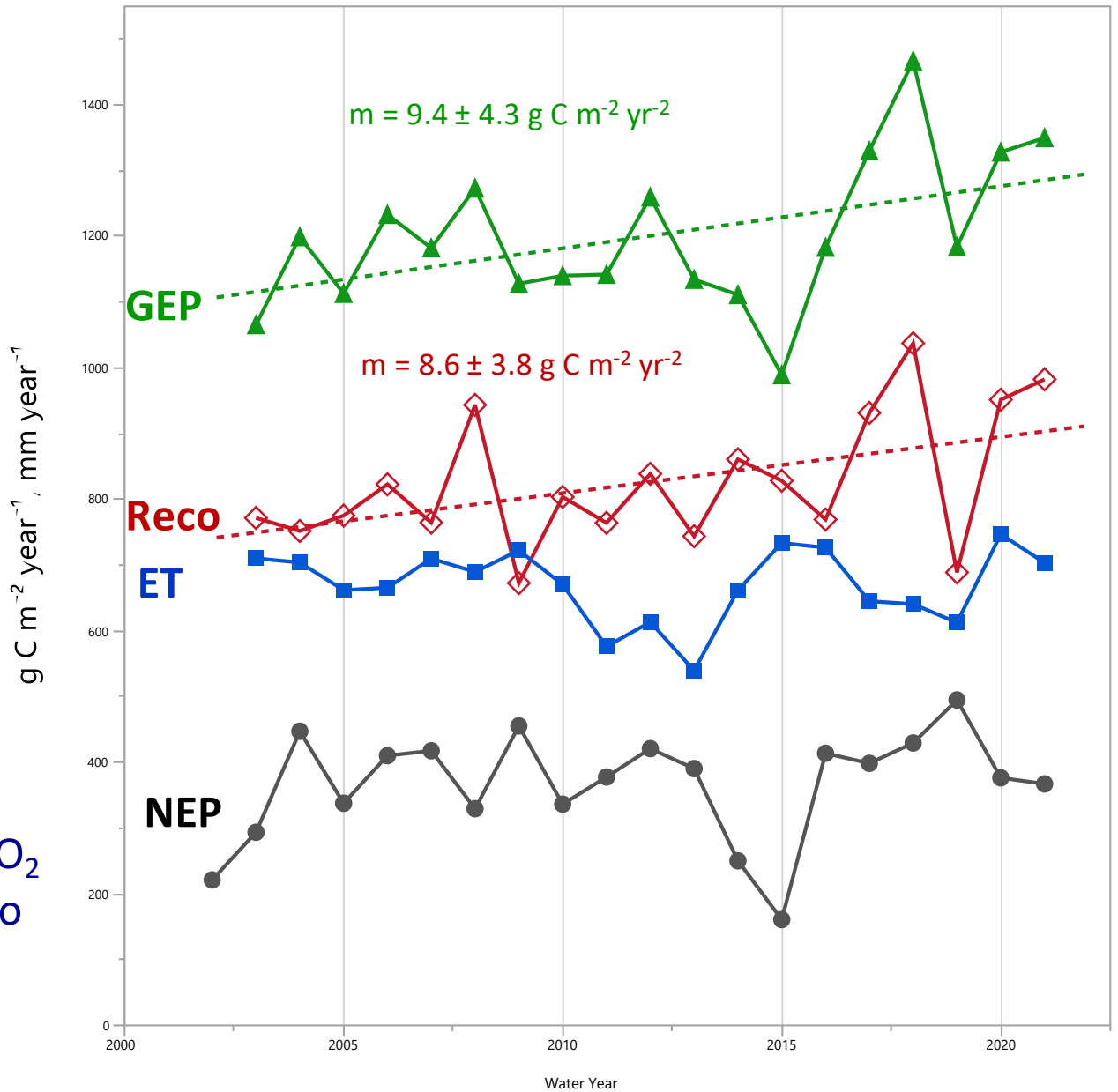
## Energy



## Atmospheric carbon + water



# Interannual Variability – Ecosystem Responses



Net ecosystem production of  $\text{CO}_2$   
 $\text{NEP} = \text{GEP} - \text{Reco}$

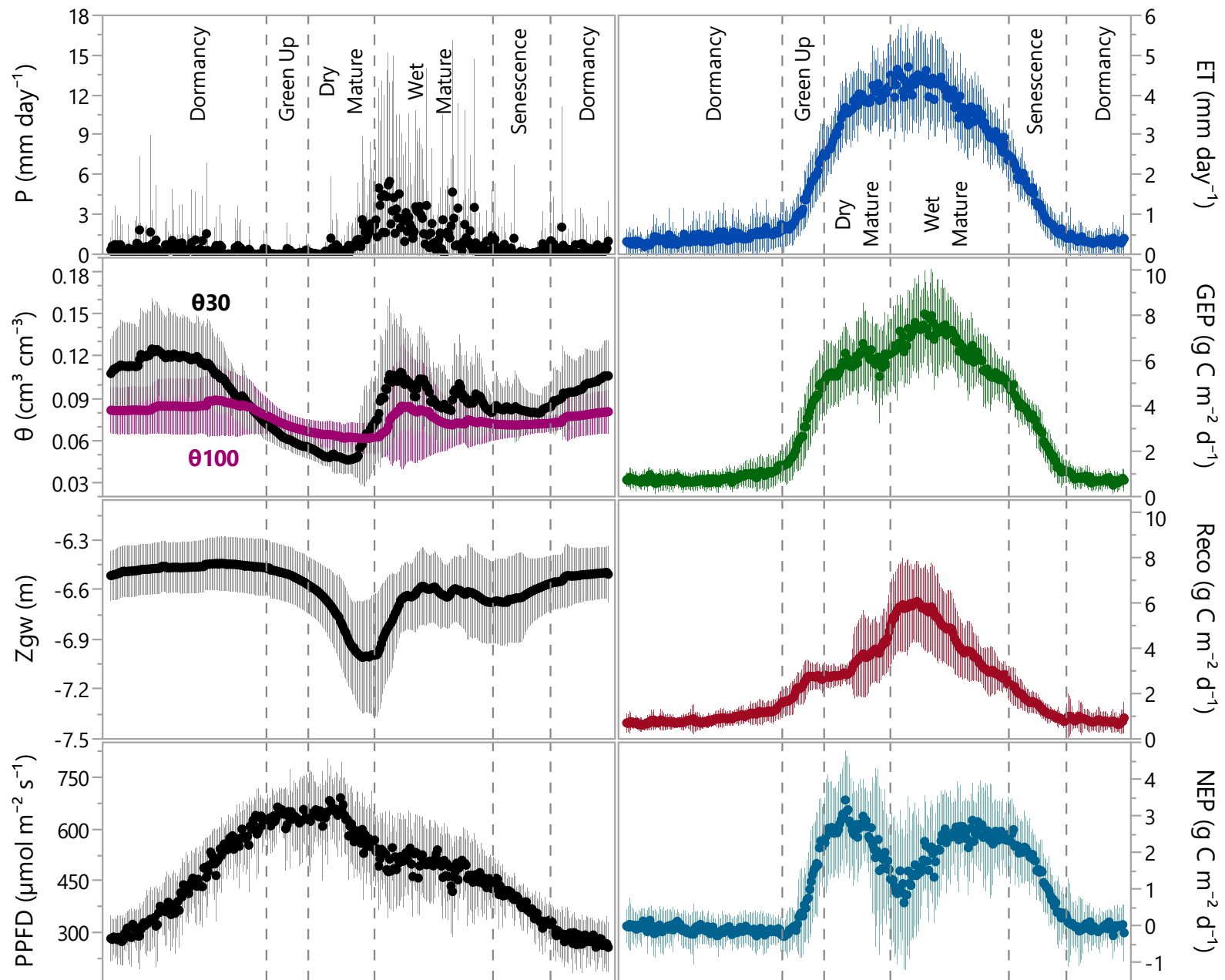
Statistics show that annual variation and trend poorly explained by hydrometeorological drivers



# Questions -

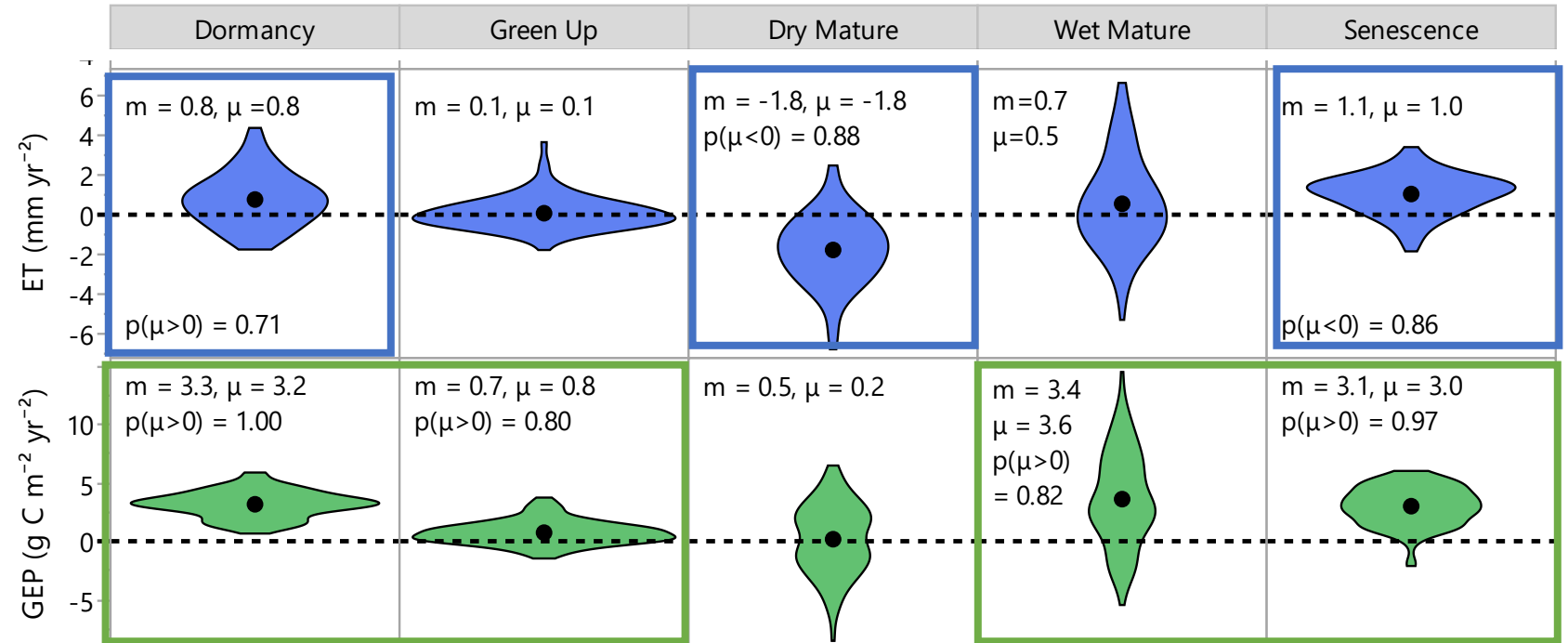
- 1) How have meteorological conditions, water and C fluxes changed at this riparian woodland over the last two decades?
- 2) What drives the interannual variability of ET and C fluxes?
- 3) How do the drivers of water and C fluxes vary throughout the annual growth cycle?

# Seasonality of the drivers and fluxes





# Changes in the seasonal fluxes



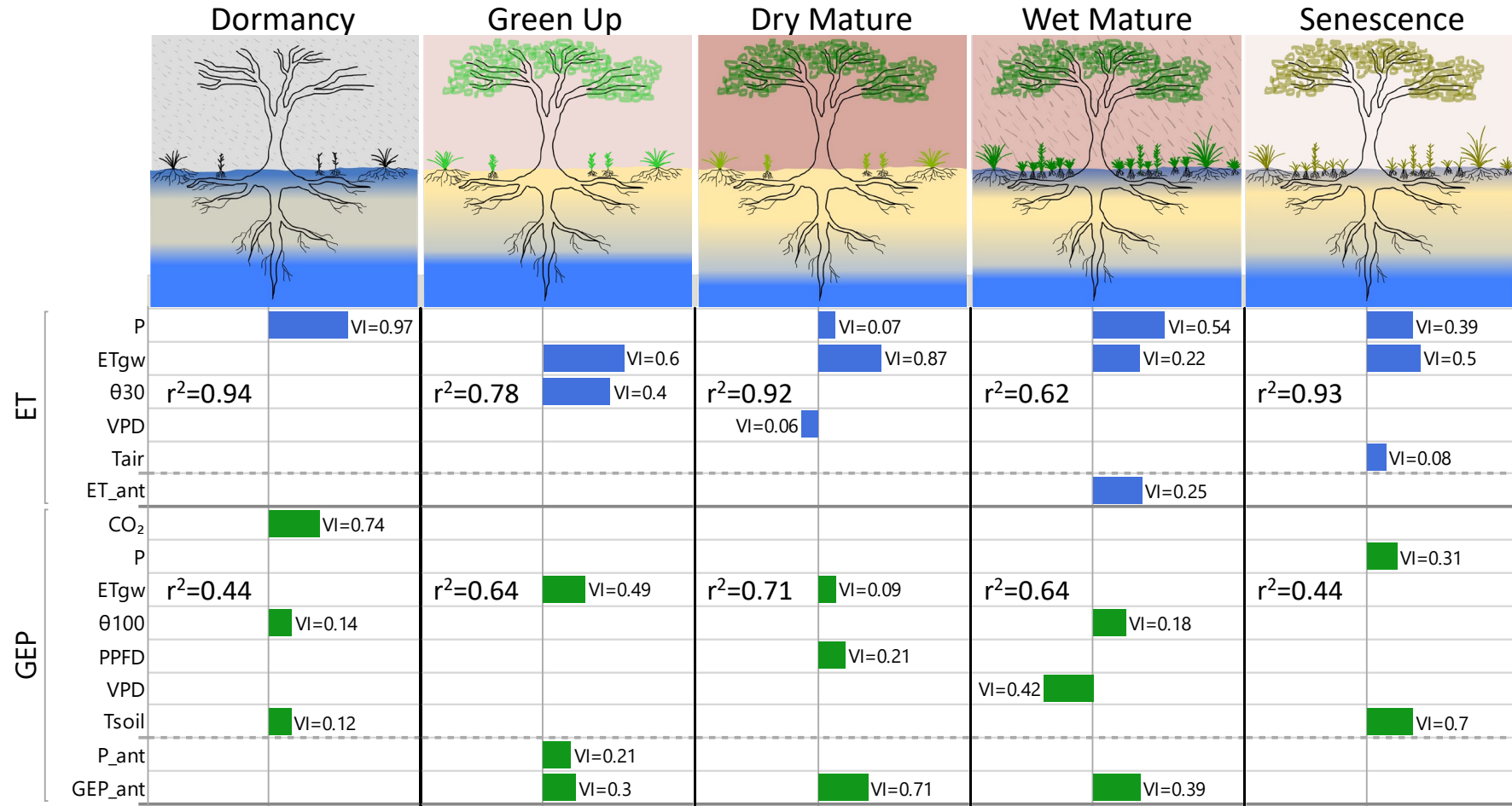
Annual variation was broken down into the seasonal scale to explain lack or presence of annual trends

- ET had positive increases in dormancy (winter) and senescence (fall) and negative trend in dry mature phase (foresummer)
- GEP (photosynthesis) increased in all seasons except the dry mature

# What drove variations in seasonal fluxes?

ET largely explained by water drivers (precip, GW use, soil moisture)

GEP explained by atmospheric CO<sub>2</sub>, water, light, atmospheric dryness (VPD), and antecedent conditions



# Take home points:

1. Groundwater buffers woodland functioning from 21<sup>st</sup> Century long-term drought
2. Riparian woodland ET exceeds precipitation but is much less than well-watered crops
3. Woodland is a substantial carbon sink. GEP and  $R_{eco}$  increased in tandem, greatest increases during:
  - Dormancy –  $CO_2$  effect, Wet Summer – increased soil moisture
4. Access to groundwater decoupled carbon and water fluxes from climate - resistance

## Questions?





*Selected bibliography: (<https://www.tucson.ars.ag.gov/unit/Publications/ASPFiles/listing.asp>)*

### **Riparian ET**

Leenhouts et al. *Hydrologic requirements of and consumptive ground-water use by riparian vegetation along the San Pedro River, Arizona*. No. 2005-5163. US Geological Survey, 2006.

Scott et al. "Interannual and seasonal variation in fluxes of water and carbon dioxide from a riparian woodland ecosystem." *Agricultural and Forest Meteorology* 122.1-2 (2004): 65-84.

Scott et al. "Multiyear riparian evapotranspiration and groundwater use for a semiarid watershed." *Journal of Arid Environments* 72.7 (2008): 1232-1246.

### **Riparian Water and Carbon Exchange**

Scott et al. "Ecohydrological impacts of woody-plant encroachment: Seasonal patterns of water and carbon dioxide exchange within a semiarid riparian environment." *Global Change Biology* 12.2 (2006): 311-324.

Scott et al. "When vegetation change alters ecosystem water availability." *Global Change Biology* 20.7 (2014): 2198-2210.

### **Long-term Fluxes**

Gallo et al. "Two decades of riparian woodland water vapor and carbon dioxide flux responses to environmental variability." *Agricultural and Forest Meteorology*, In press

### **Riparian Mesquite Ecohydrology**

Barron-Gafford et al. "Hydraulic redistribution buffers climate variability and regulates grass-tree interactions in a semiarid riparian savanna." *Ecohydrology* 14.3 (2021): e2271.

Yepes et al. "Intraseasonal variation in water and carbon dioxide flux components in a semiarid riparian woodland." *Ecosystems* 10 (2007): 1100-1115.

Pott et al. "Sensitivity of mesquite shrubland CO<sub>2</sub> exchange to precipitation in contrasting landscape settings." *Ecology* 89.10 (2008): 2900-2910.

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