Controls over carbon and water fluxes by vegetation, soils, and climate

Mitchell Pavao- Zuckerman
Travis Huxman
Dept. of Ecology and Evol. Biology
University of Arizona

This presentation contains unpublished data and should not be cited without author permission.

Acknowledgements

Huxman Lab
- Greg Barron-Gafford
- Jessie Cable
- Alex Eilts
- Danielle Ignace
- Mike Mason
- Dan Potts
- Anna Tyler

Russell Scott

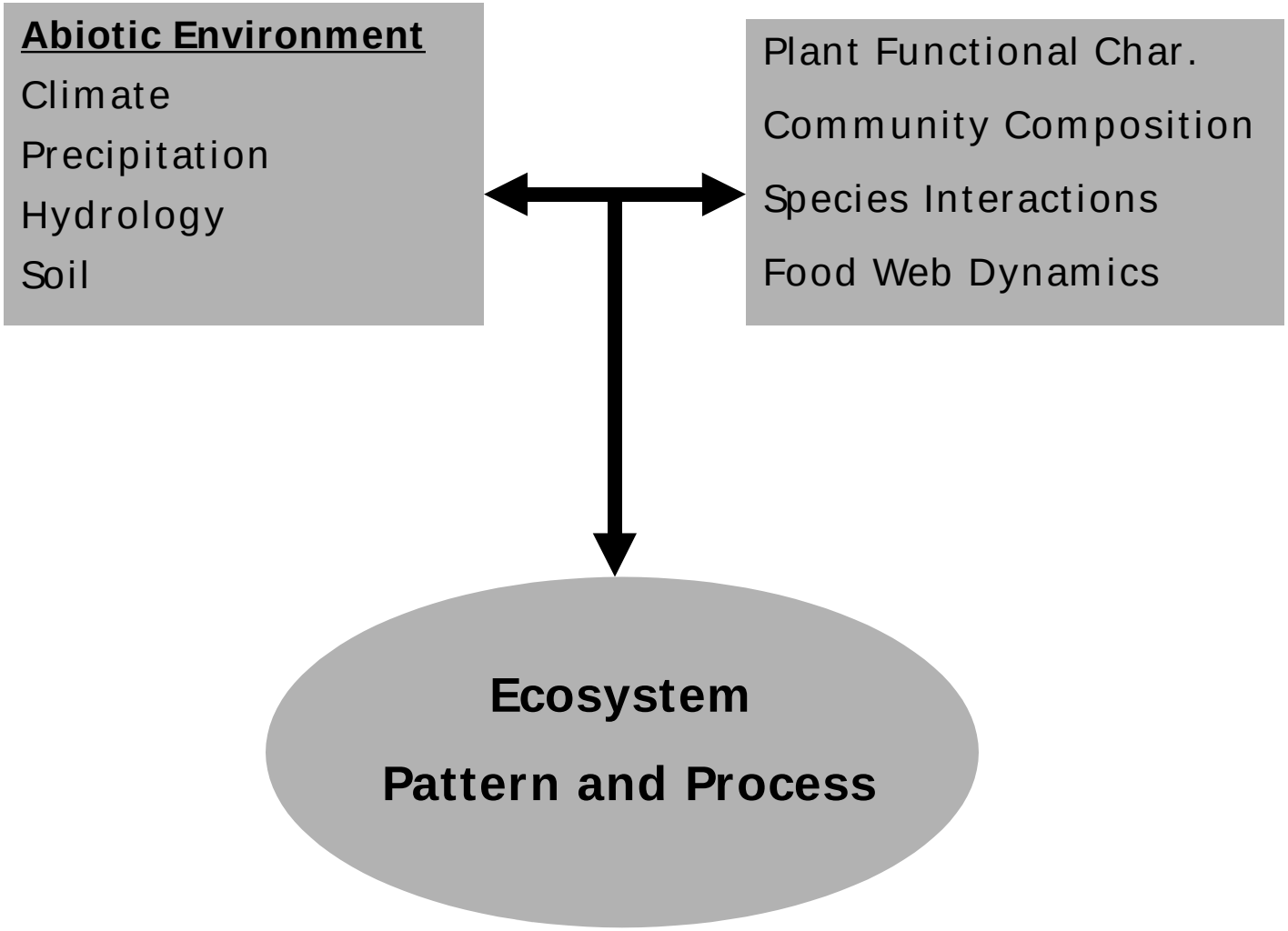
Bill Cable

Dave Williams

Jake Weltzin

Enrico Yepez

SAHRA, NSF, IALC, USDA, University of Arizona


Abiotic Environment
Climate
Precipitation
Hydrology
Soil
Plant Functional Char.
Community Composition
Species Interactions
Food Web Dynamics
Ecosystem
Pattern and Process

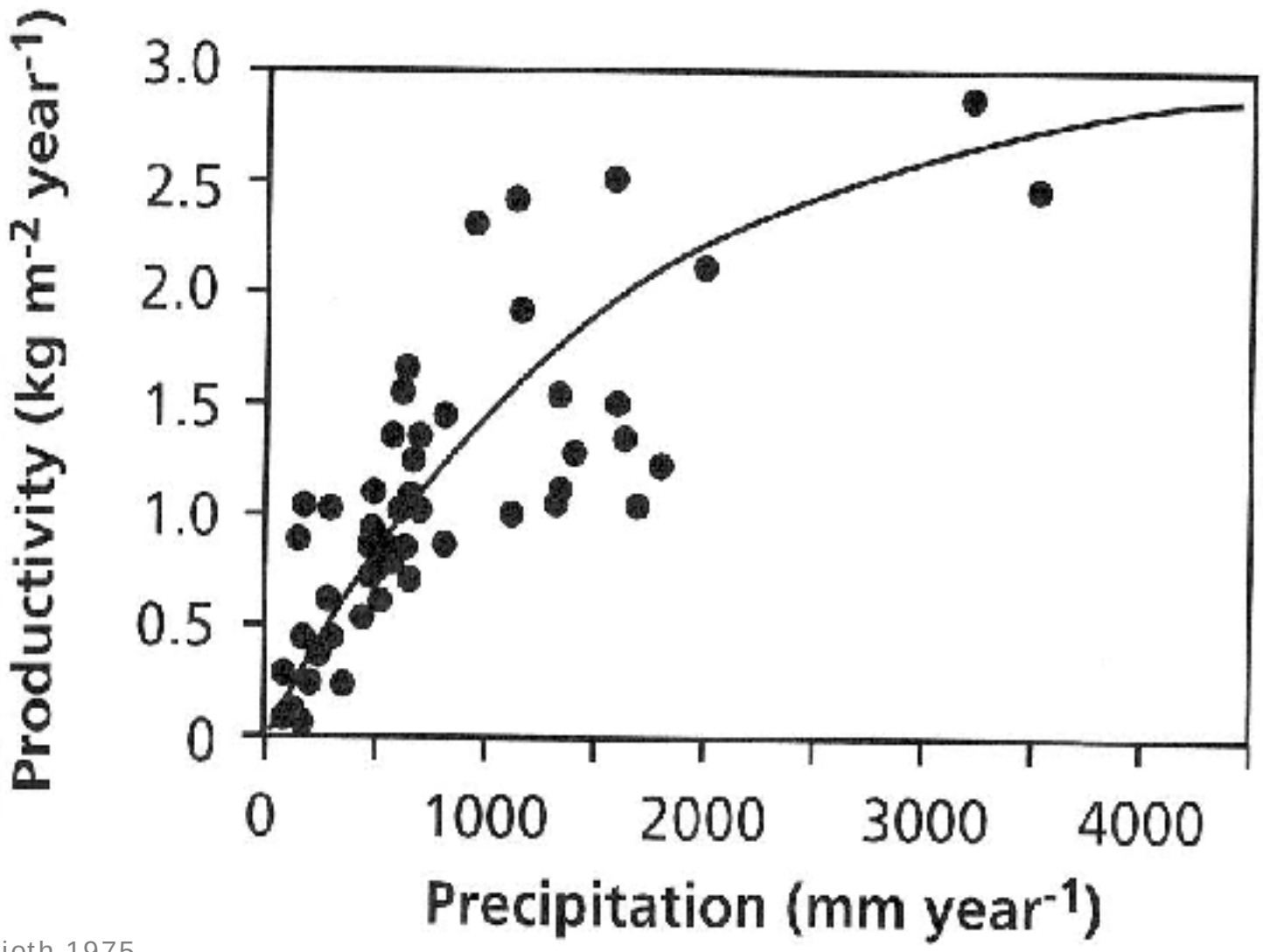
Big Questions!

What is the role of precipitation frequency in controlling ecosystem processes?

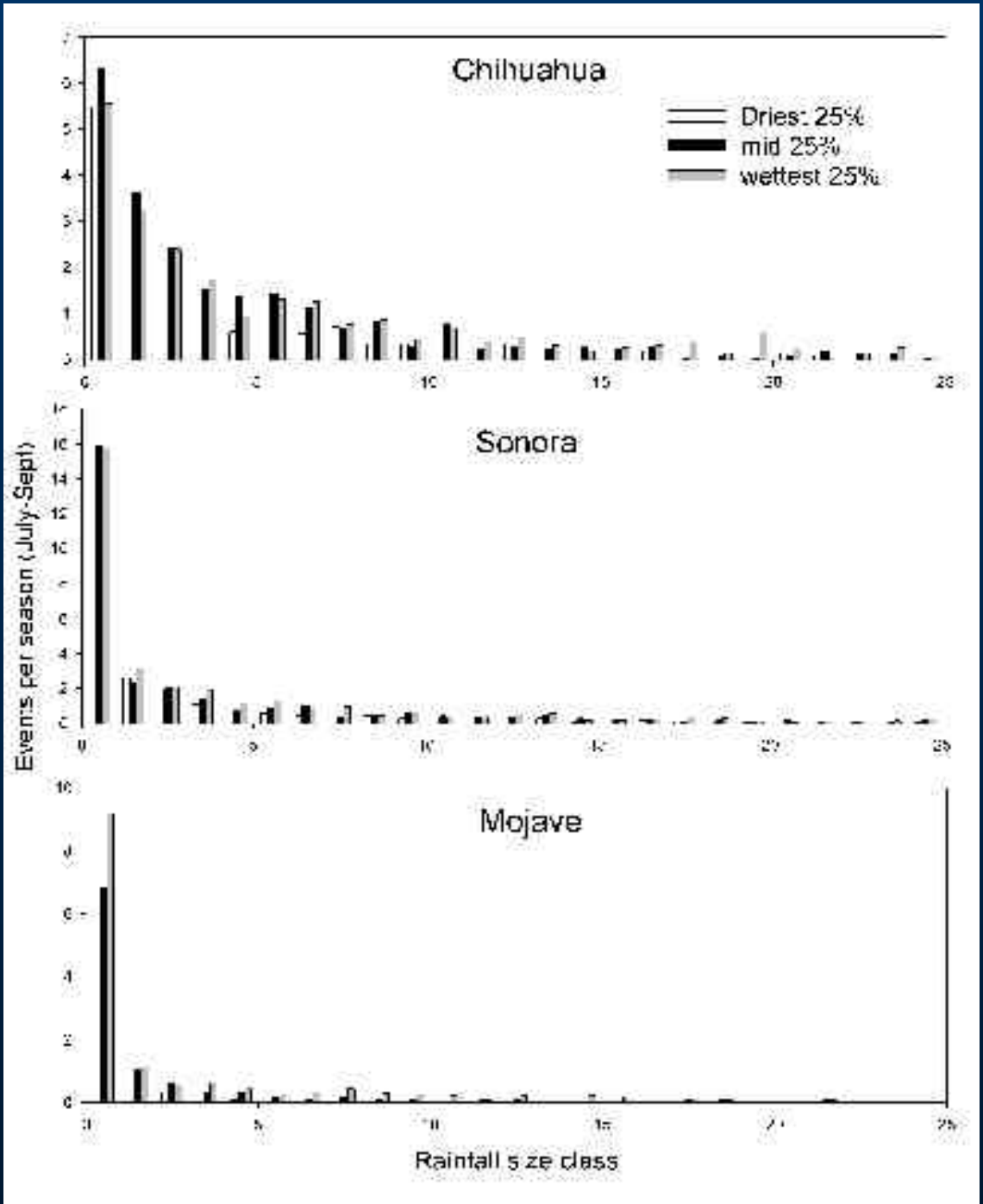
How do autotrophs and heterotrophs differ in their responses to precipitation pulses?

How (and how often) are water and carbon cycles coupled?

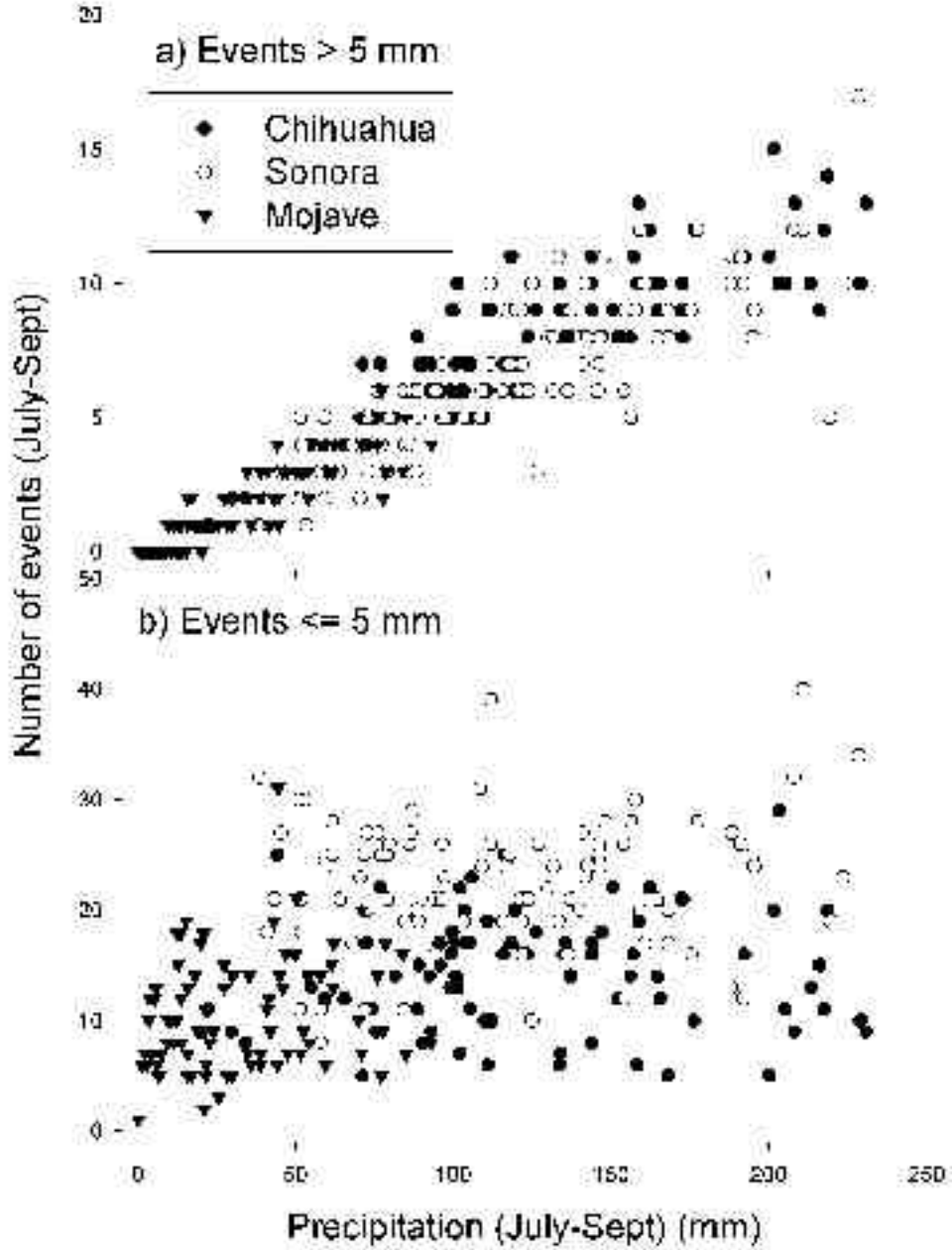
What is the role of physical factors (interception, infiltration, runoff, redistribution, soil evaporation) in controlling ecosystem response to rain on different time scales?


Productivity (kg m-2 year-1)
3.0
2.5
2.0
1.5
1.0
0.5
0
0
1000
2000
3000
4000
Precipitation (mm year-1)

Lieth 1975



Many more small precipitation events than large events



Event Size

For big events:

More precip correlated with more events

For small events:

No relationship between # and total precip

Questions…

What is the response of ecosystem processes to a single precipitation event?

How do native and non- native grasses differ in their responses to precipitation pulses?

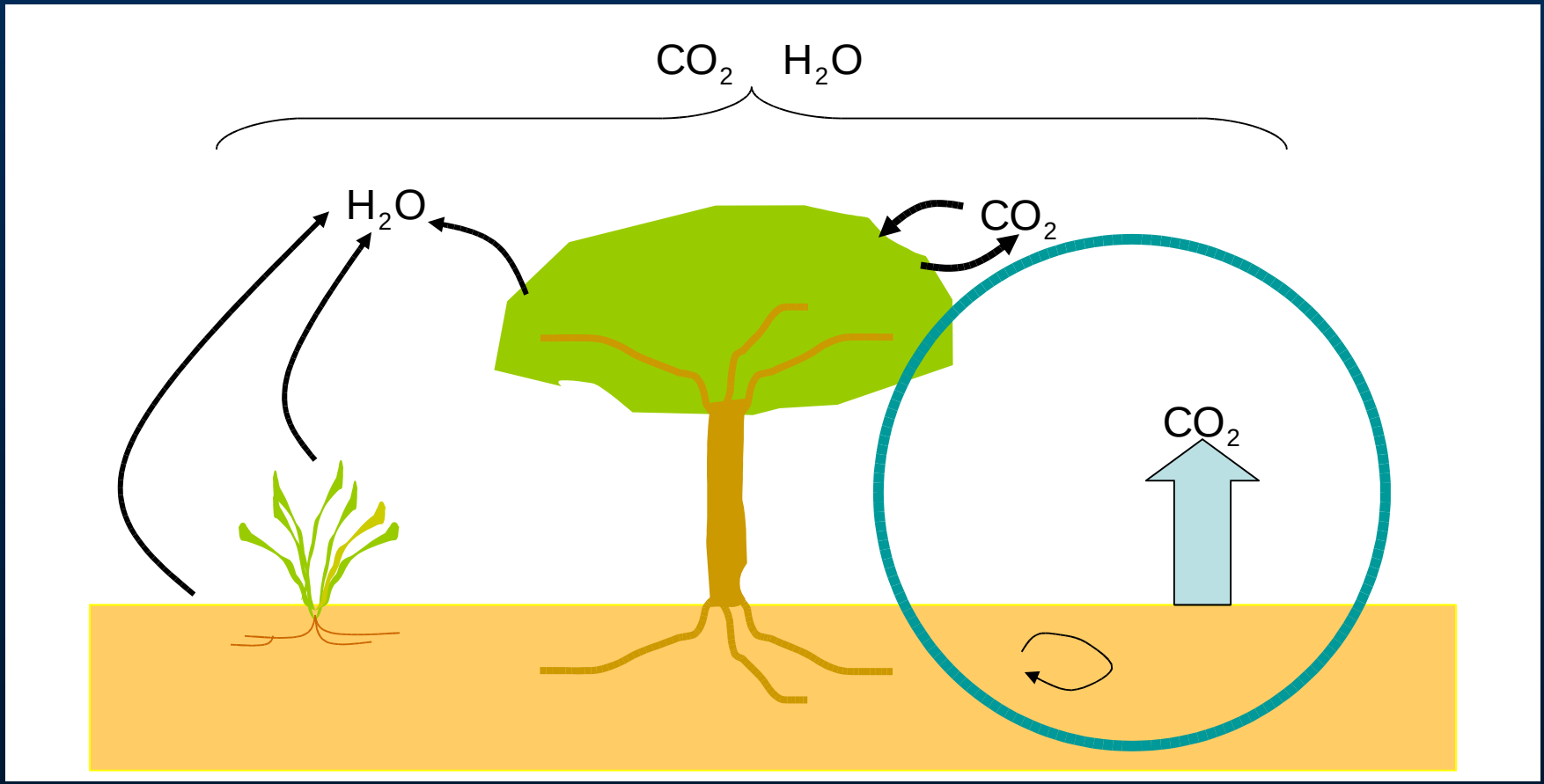
Santa Rita Experimental Range

Santa Rita Experimental Range

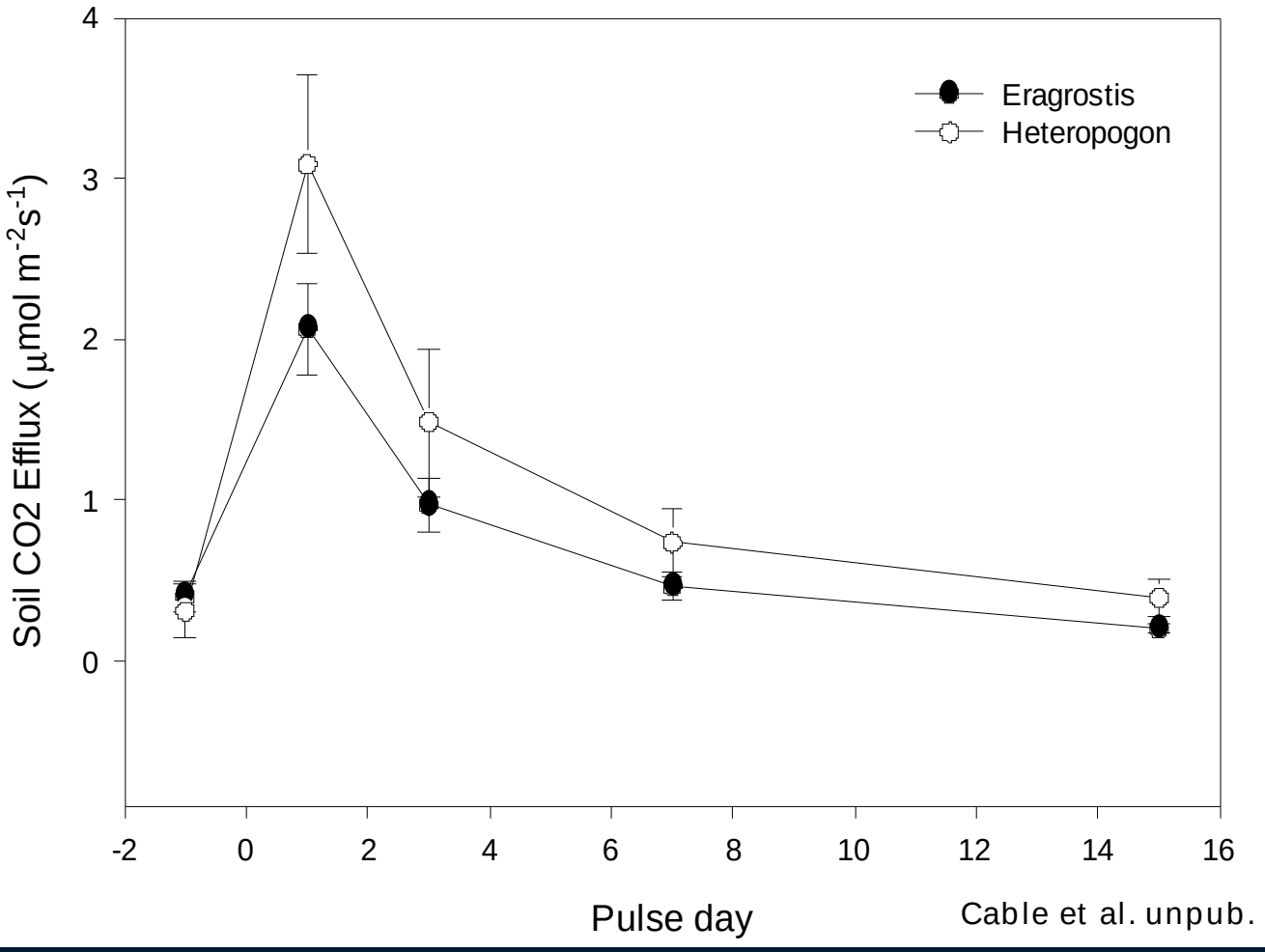
Rainout shelters on a sandy and clay rich soil

Stands of native (*Heteropogon contortus*) and non-native (*Eragrostis lehmanniana*) grass species

Experimental manipulation of monsoon precip. (wet = +50% & dry = -50%) – equivalent winter, spring and fall precip.


CO_2 H_2O
H_2O
CO_2
CO_2

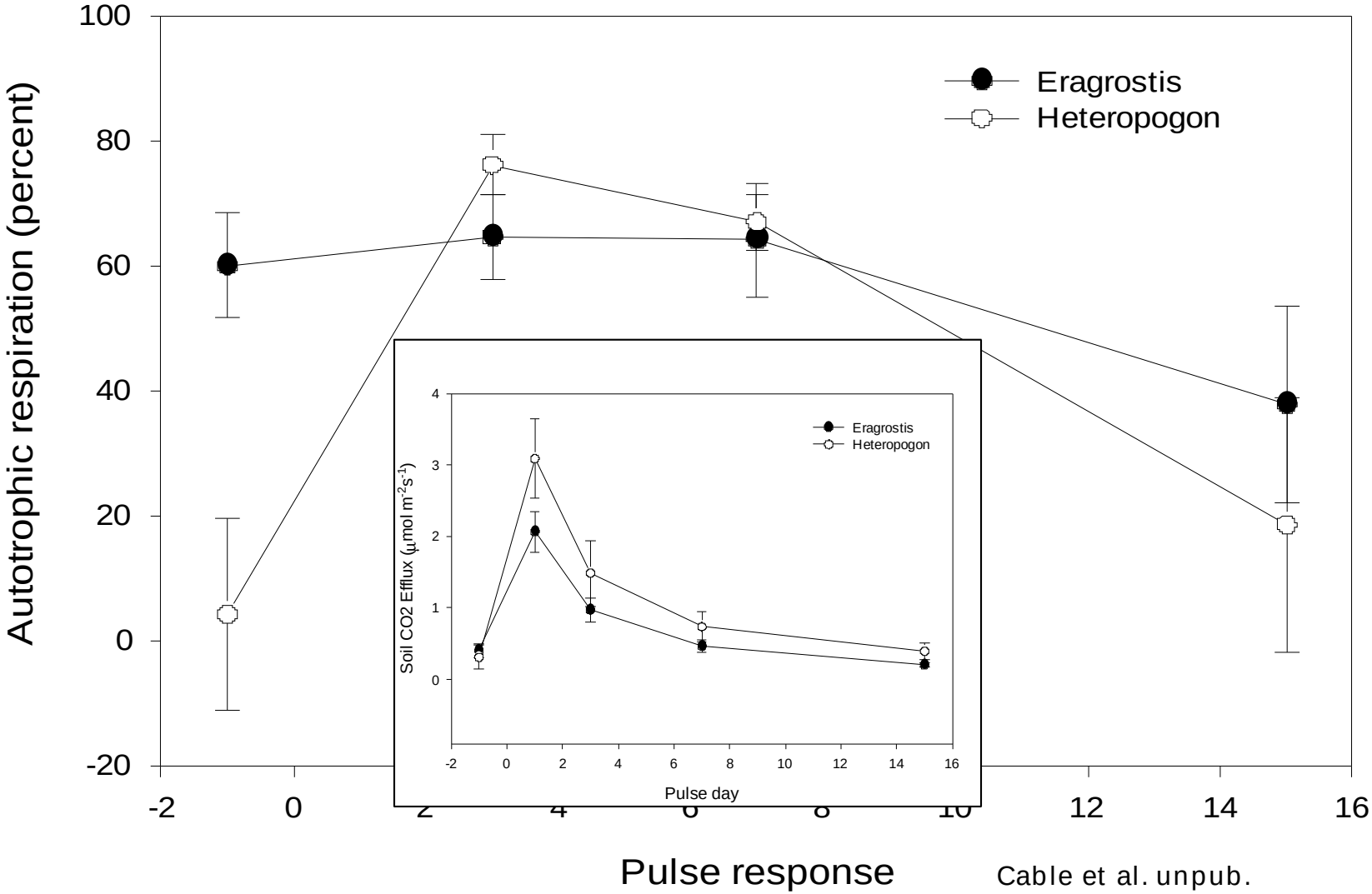
Soil respiration



Soil efflux ↑ following pulse addition

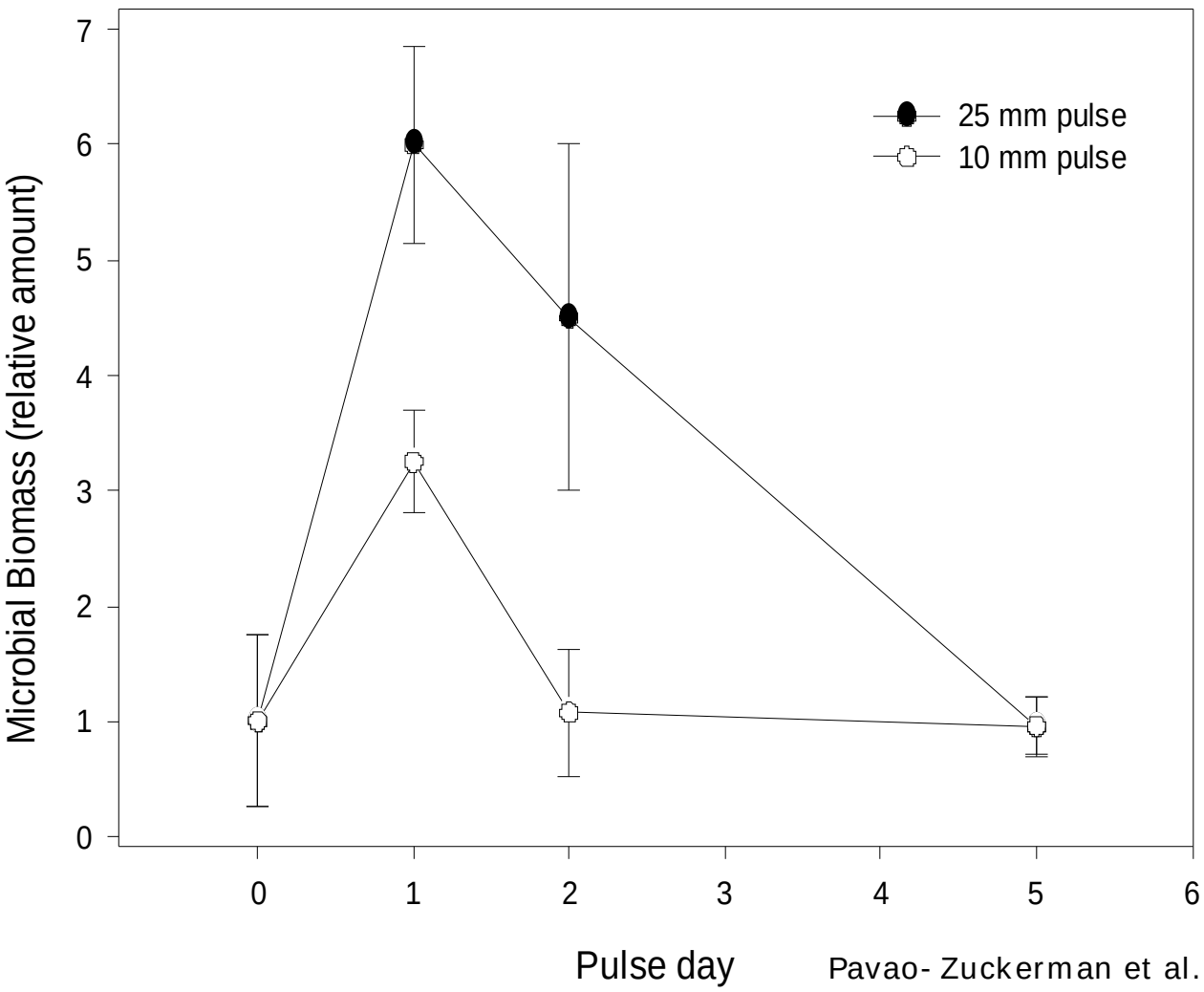
Similar time course following pulse

Increased Soil Respiration Dominated by Autotrophs



Cable et al. unpub.

Soil Microbial Biomass

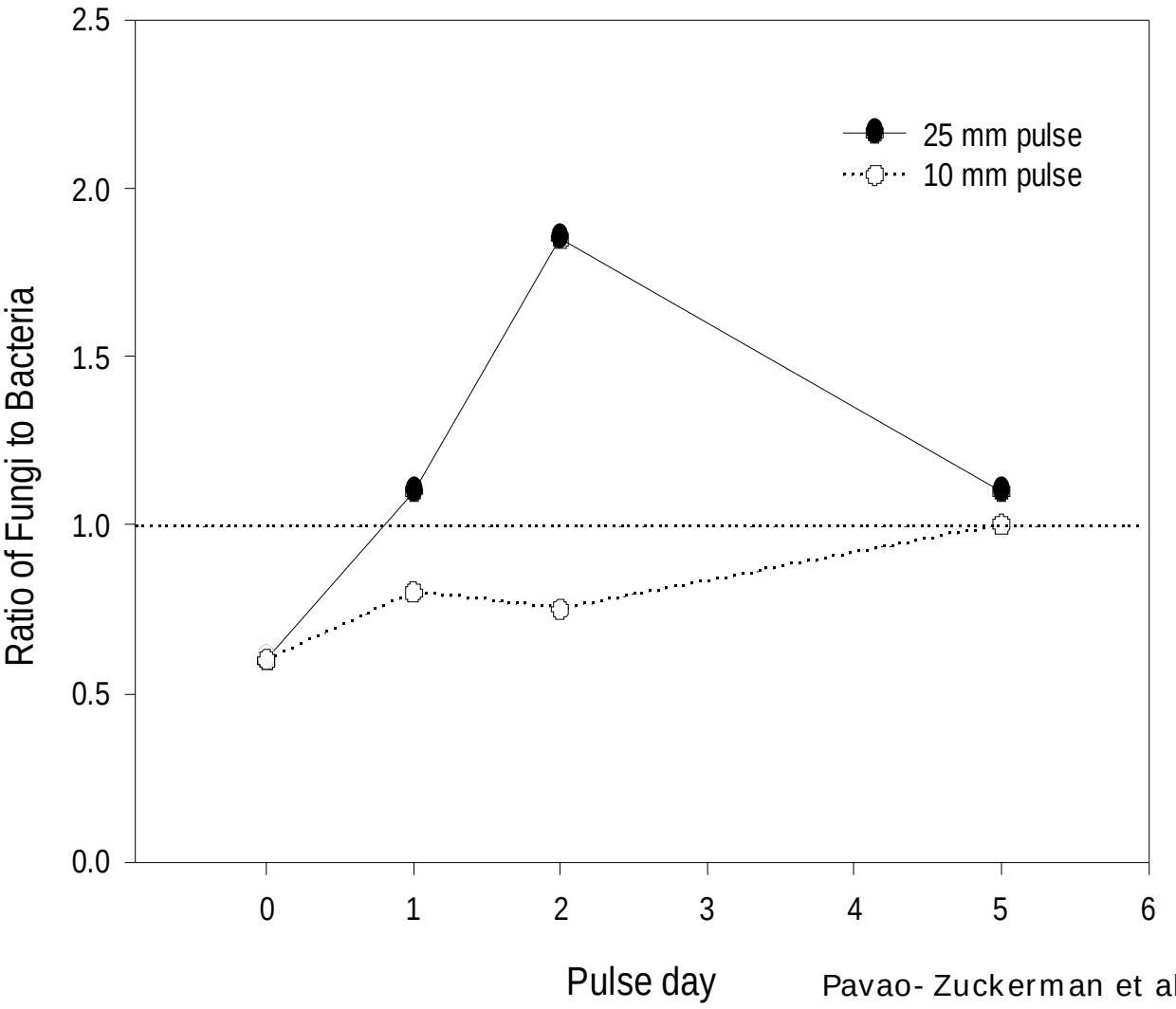


Pavao- Zuckerman et al.

Microbial pop ↑ with pulse addition

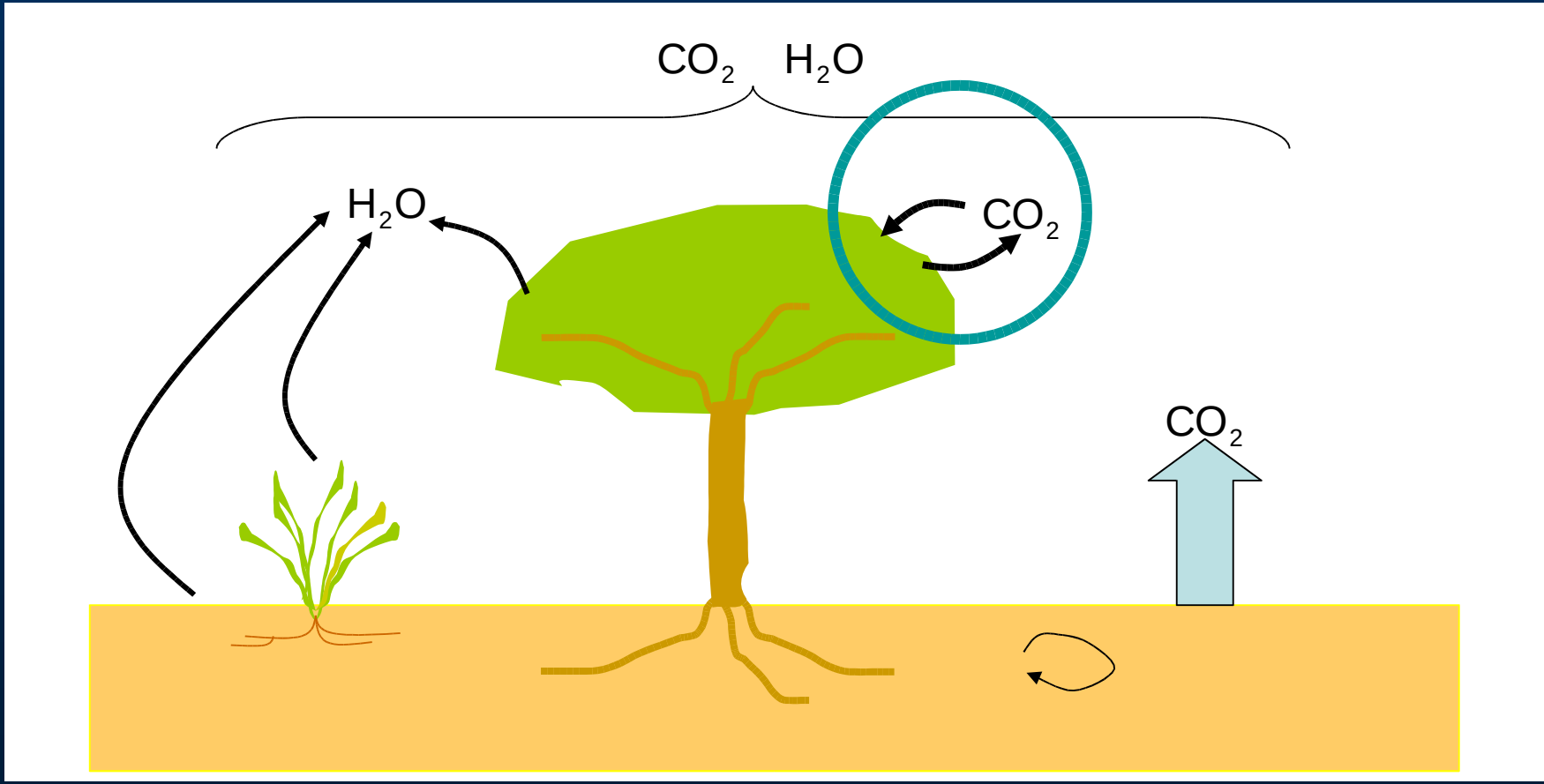
Response drive by pulse size

Microbial community composition

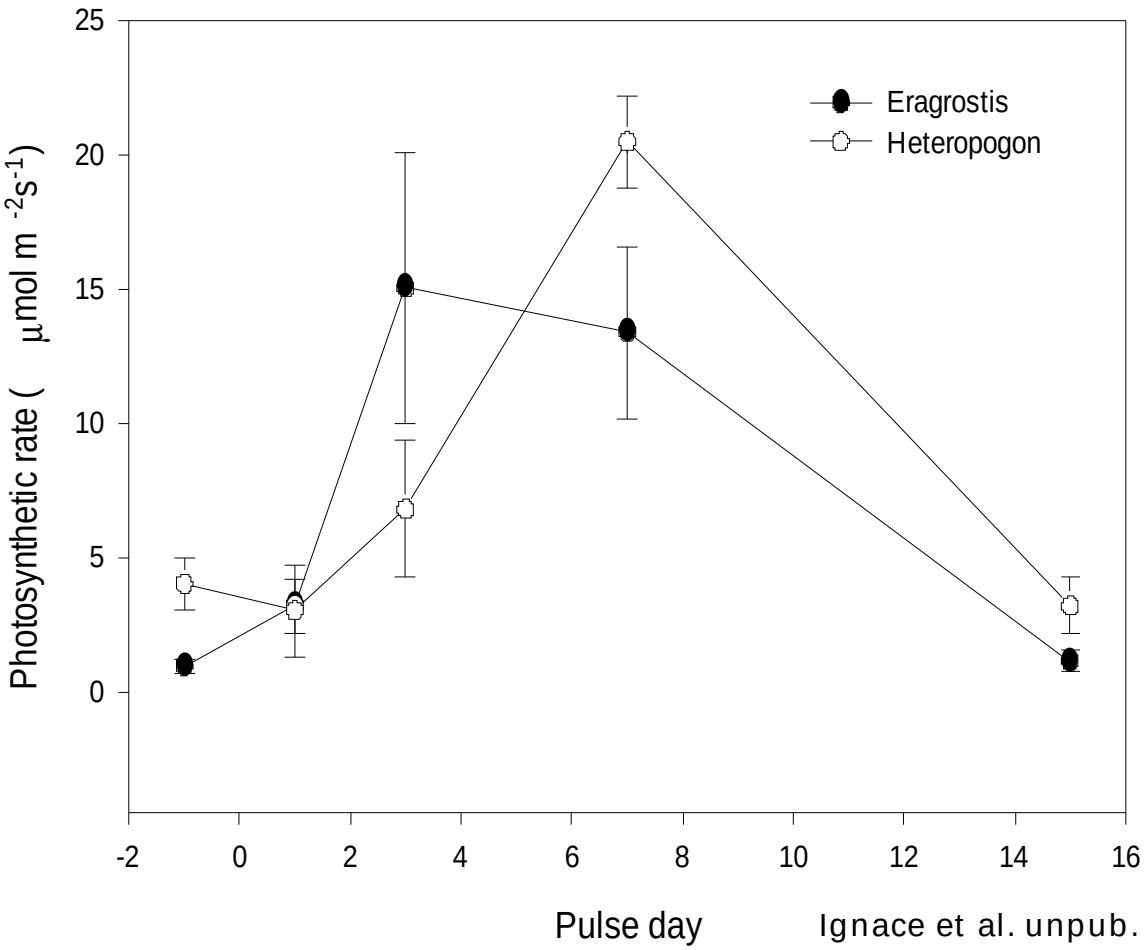


Pavao-Zuckerman et al.

Fungi become dominant only with larger pulse addition


CO_2 H_2O
H_2O
CO_2
CO_2

Leaf level photosynthetic response

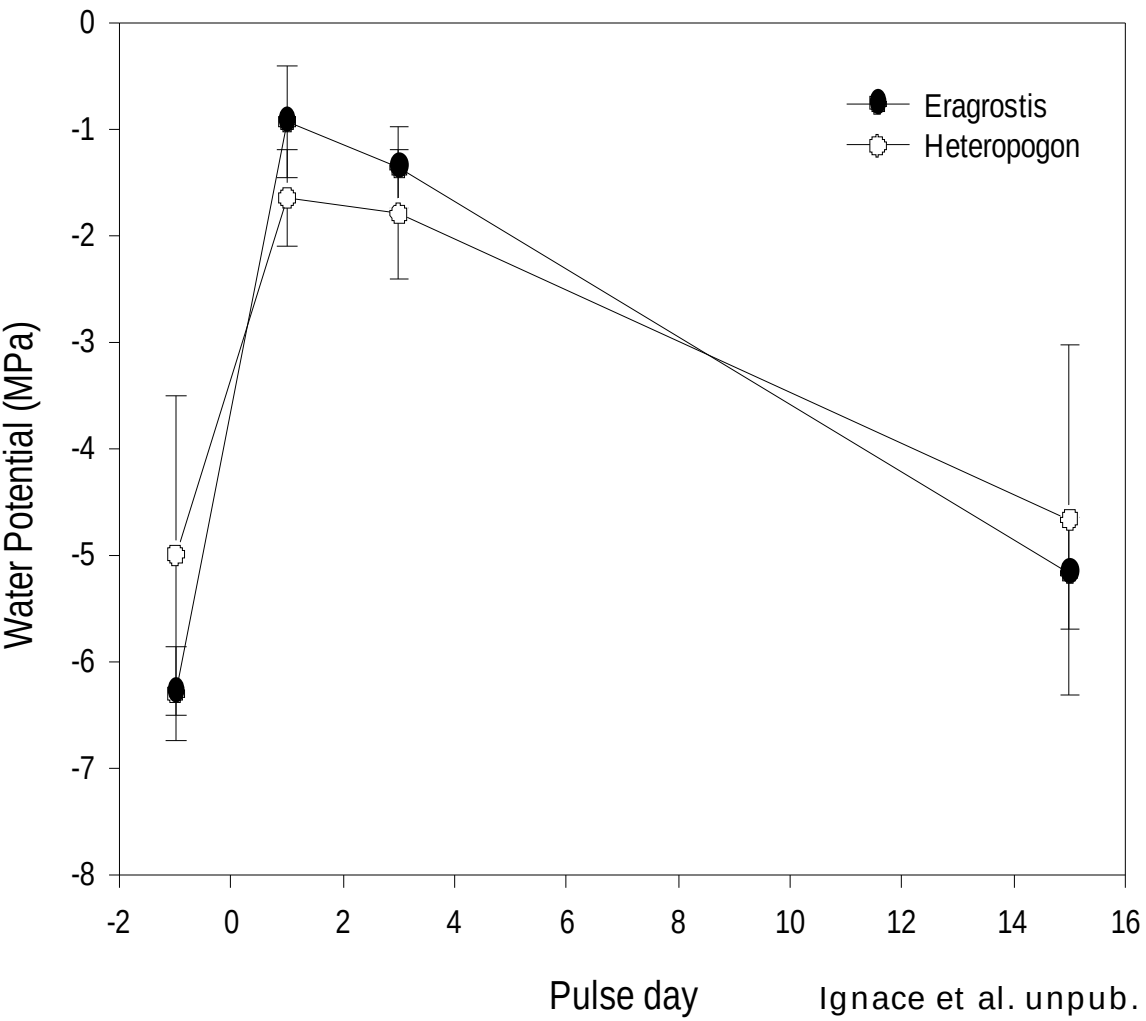


Ignace et al. unpub.

Both species assimilate C in response to available water

Time course is out of synch

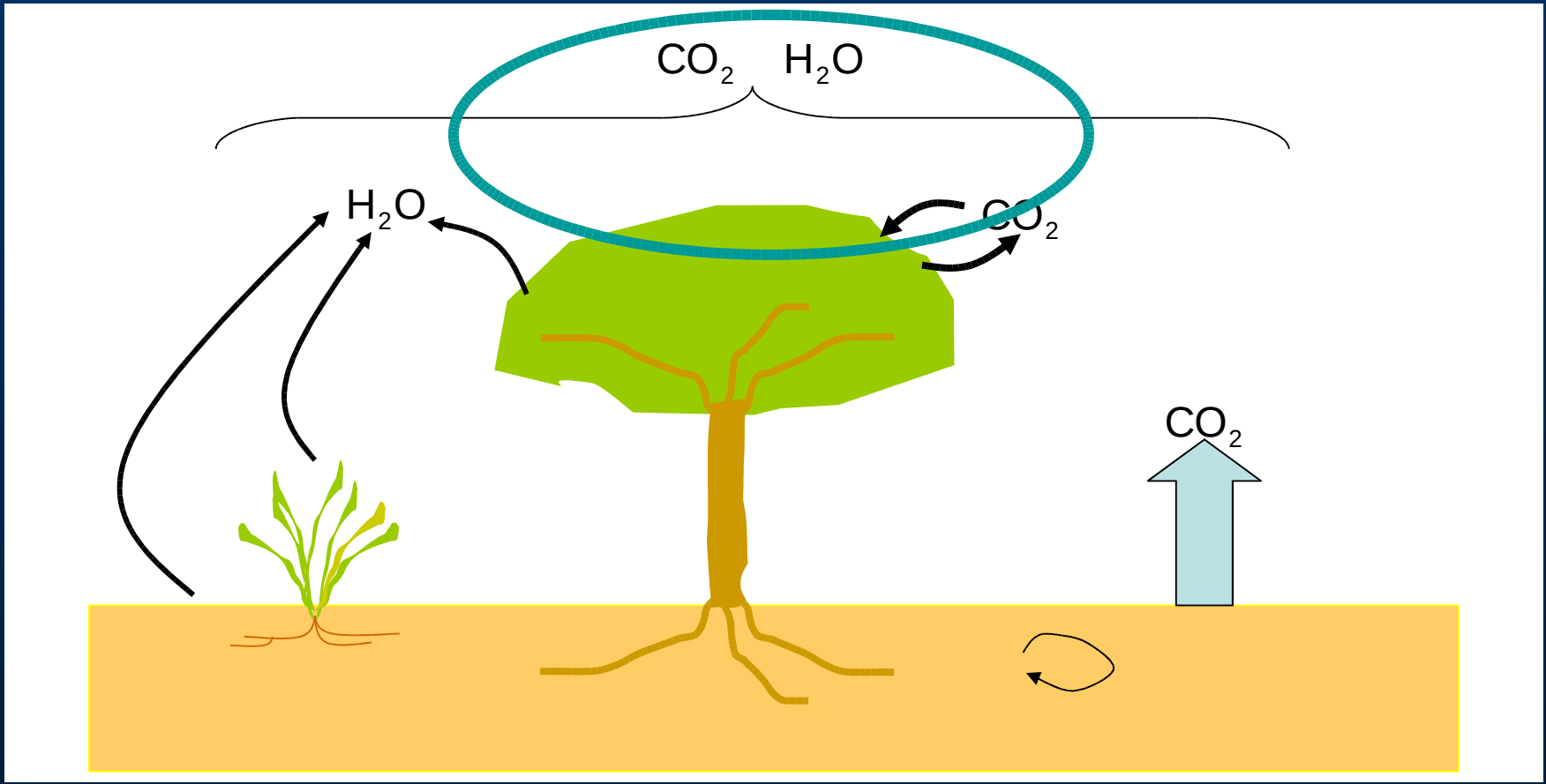
Pre- Dawn Water Potential



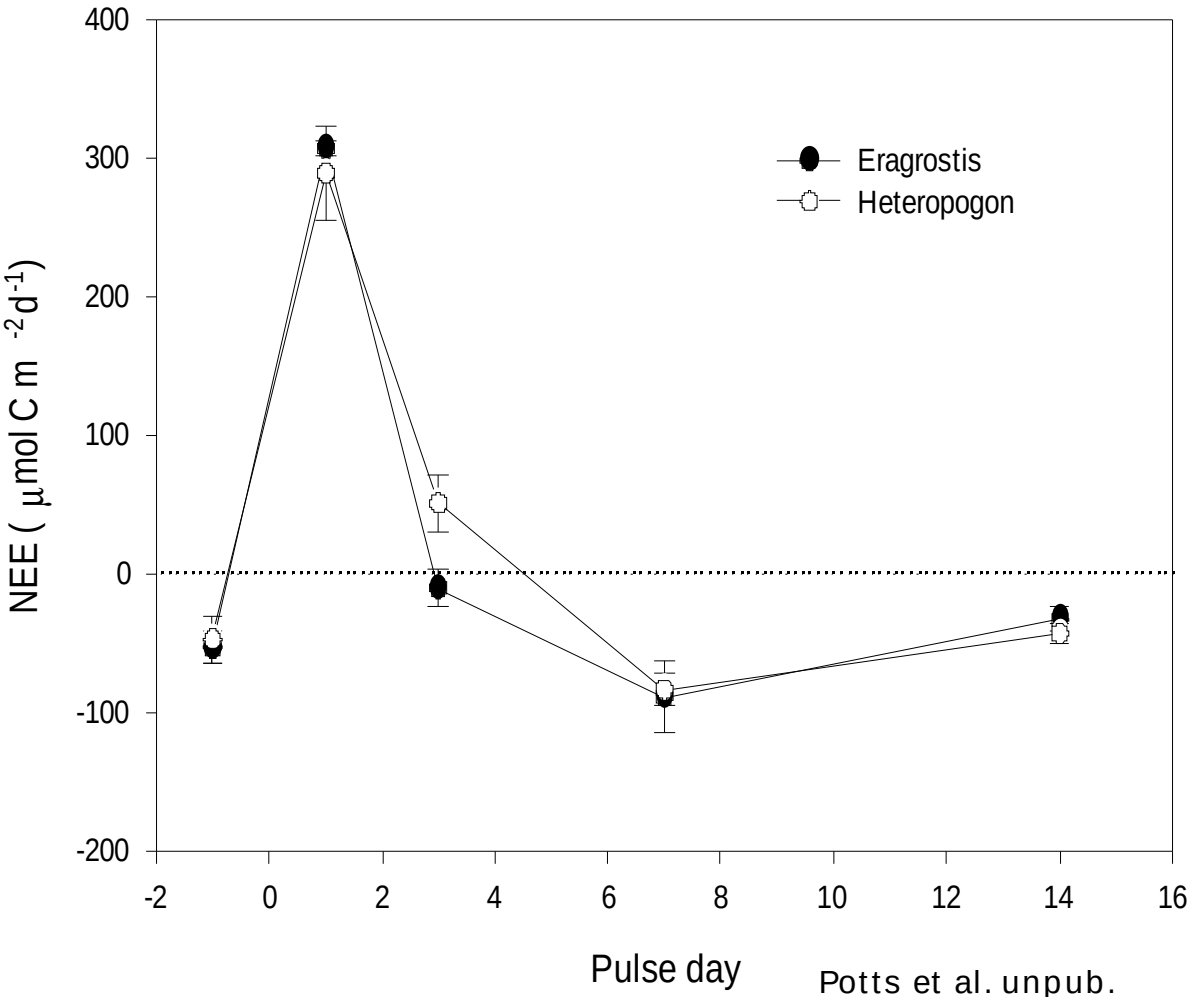
Ignace et al. unpub.

Plants become less negative

Time- course in response to soil moisture


CO_2 H_2O
H_2O
CO_2
CO_2

Net Ecosystem Exchange

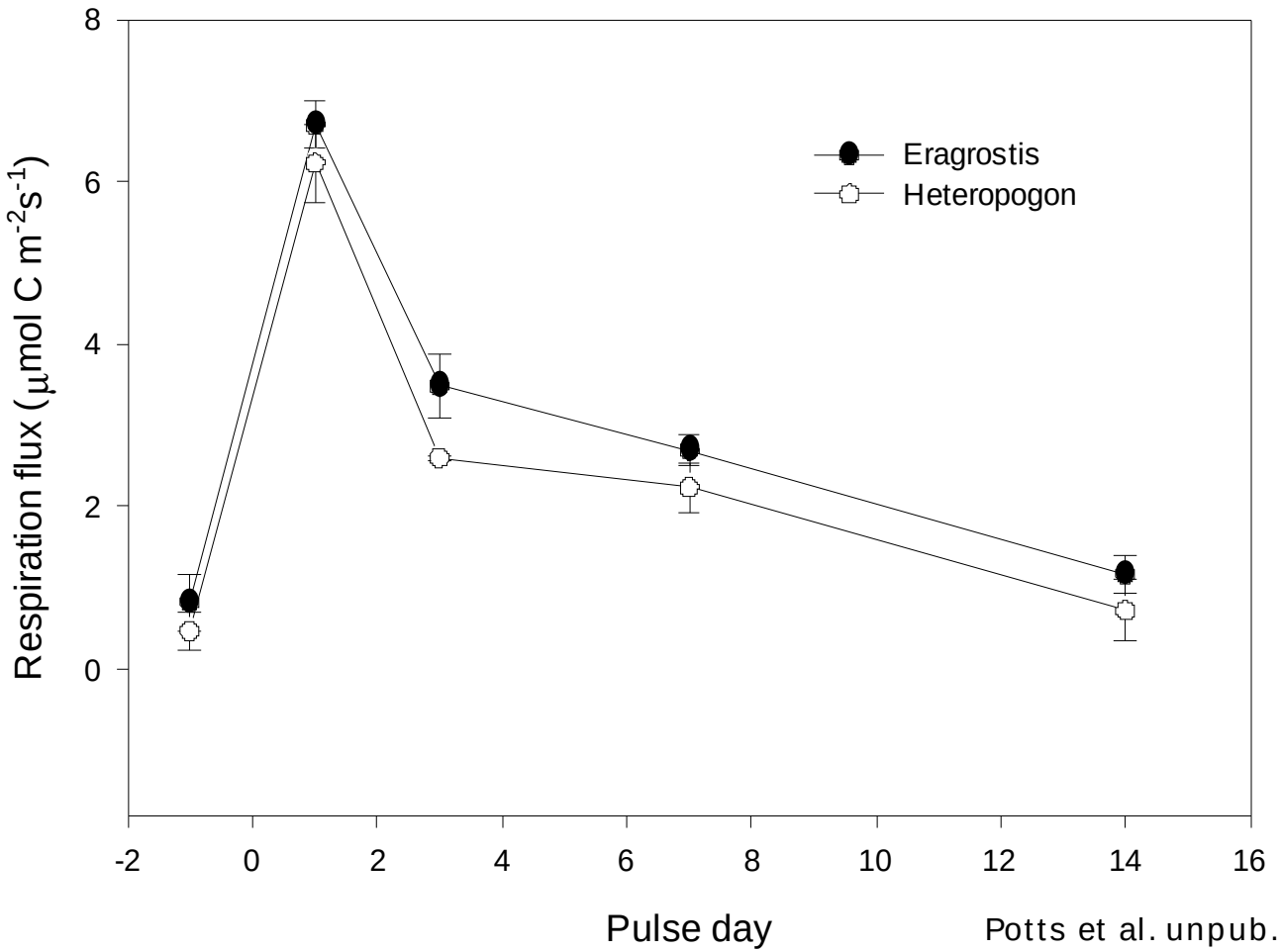


Potts et al. unpub.

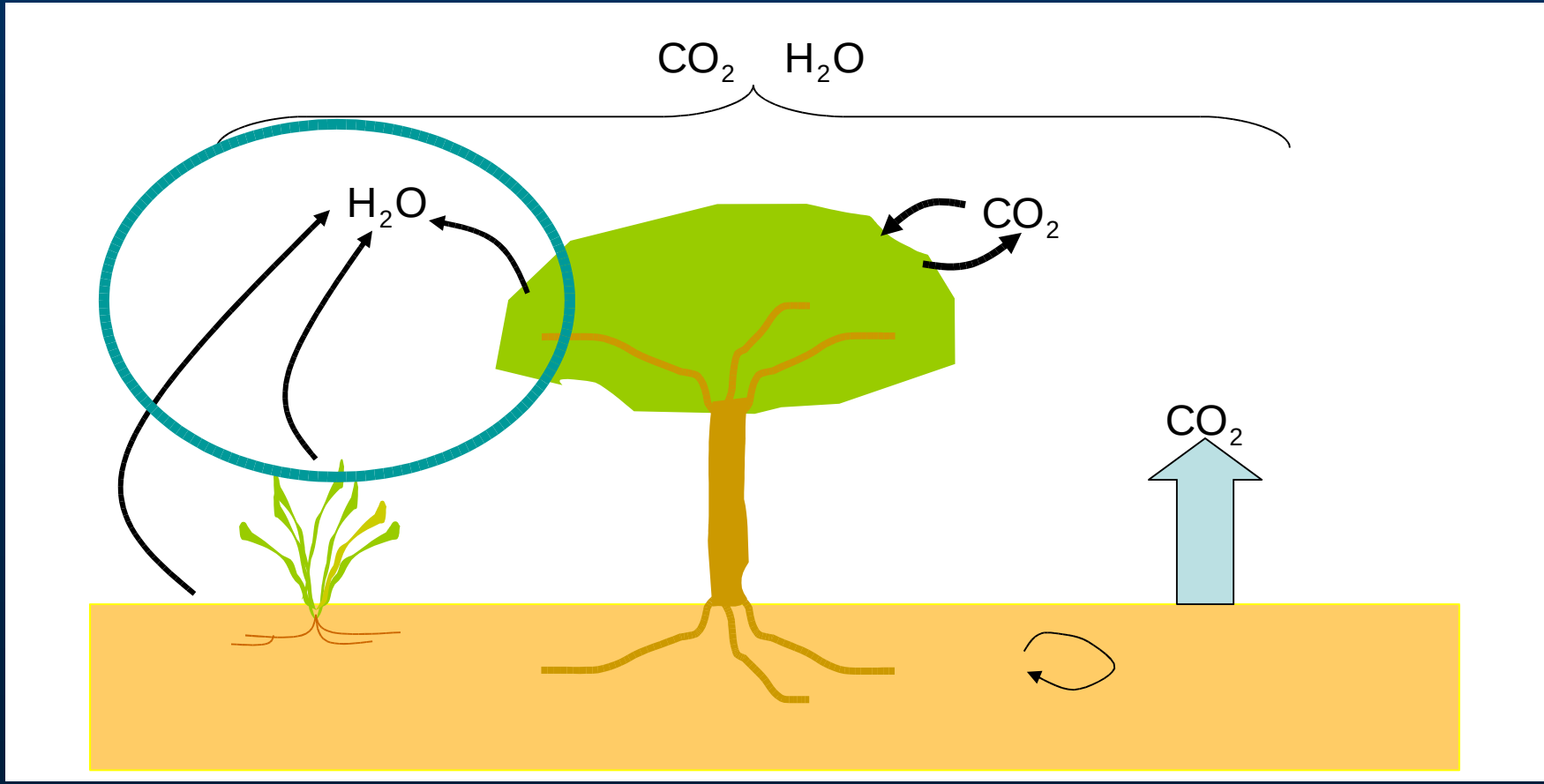
Initial: flush of CO_2

System becomes net sink for C

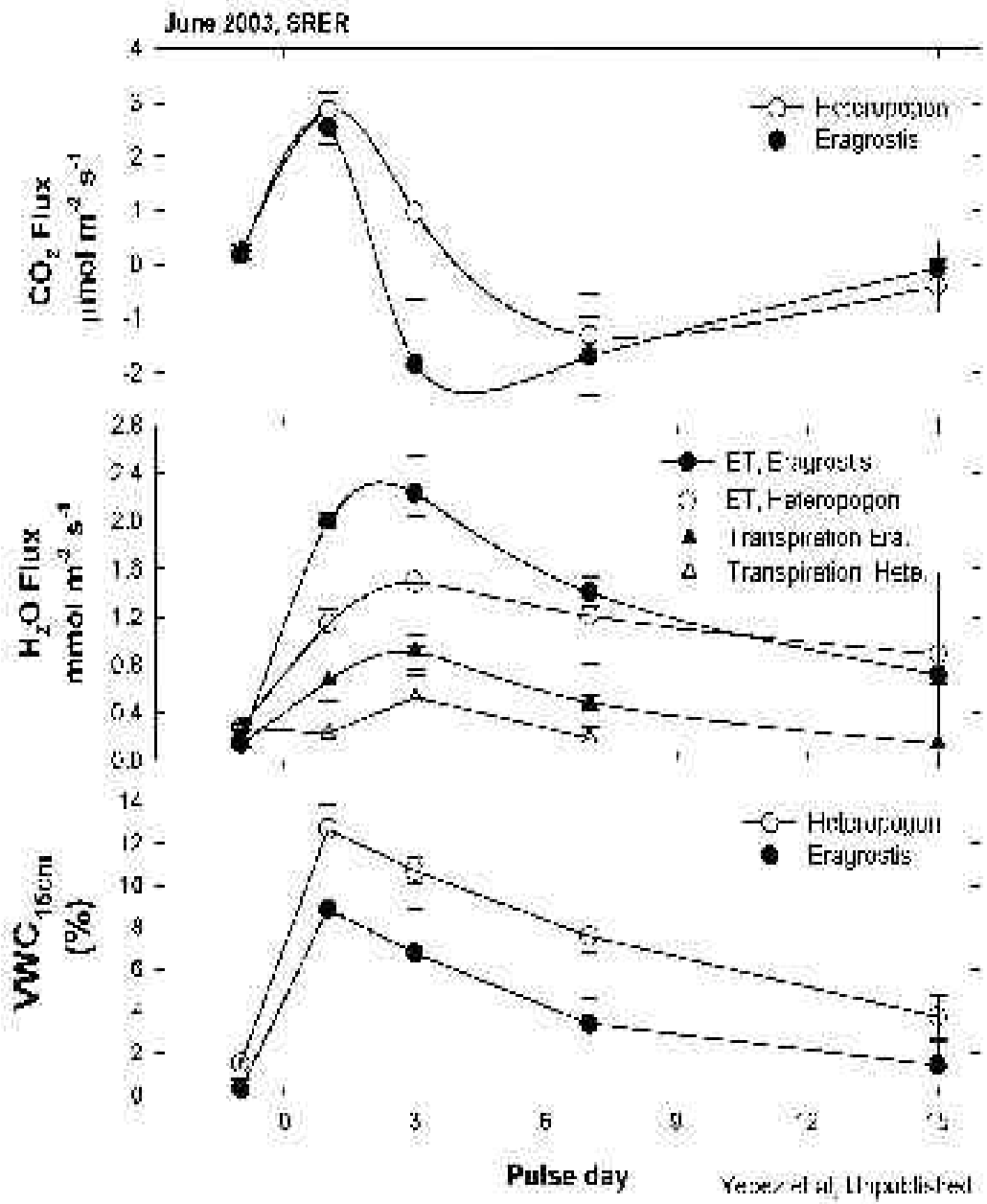
Ecosystem respiration increases following the pulse



Potts et al. unpub.


CO_2 H_2O
H_2O
CO_2
CO_2

Whole- plot water response



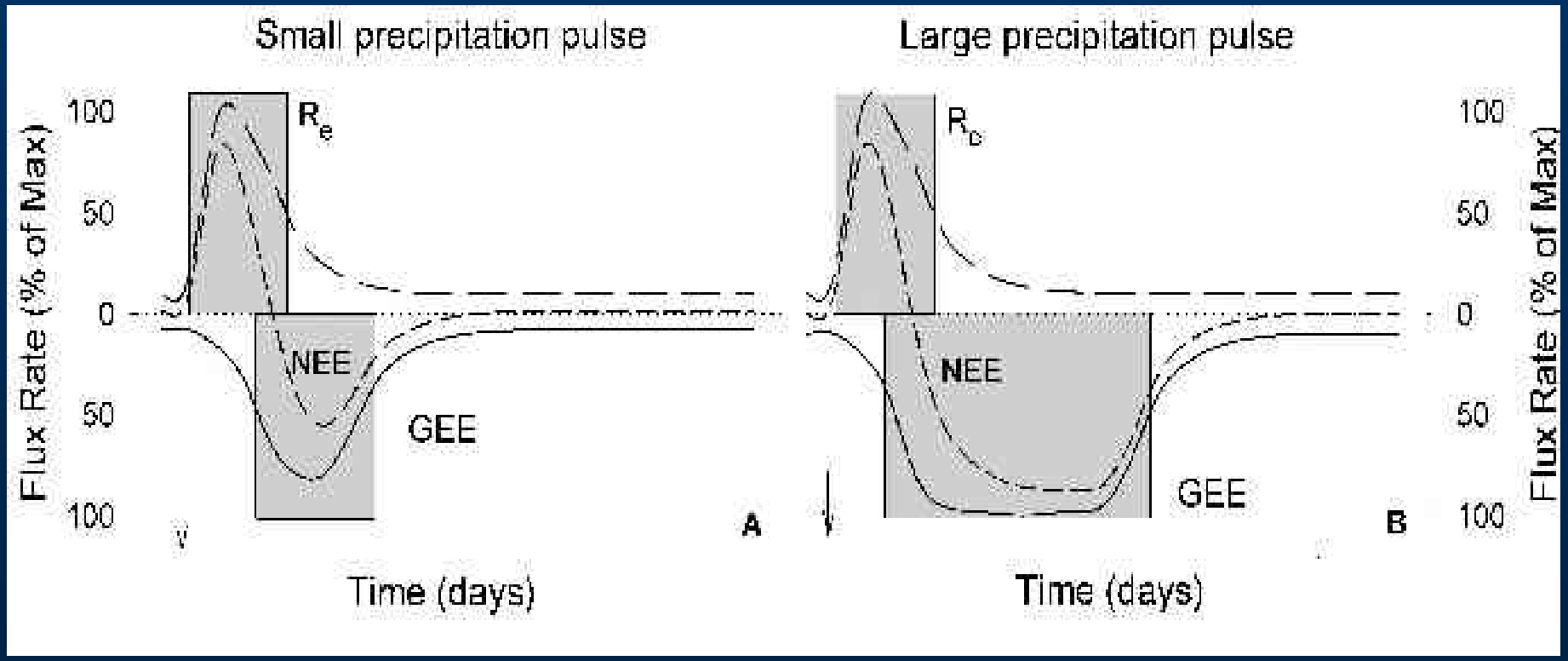
Time course in CO_2 flux and ET that differs between species

Interaction of soil water and CO_2 flux

Response of ecosystem processes to a single precipitation event?

Native and non- native grasses respond differently to a single precipitation event

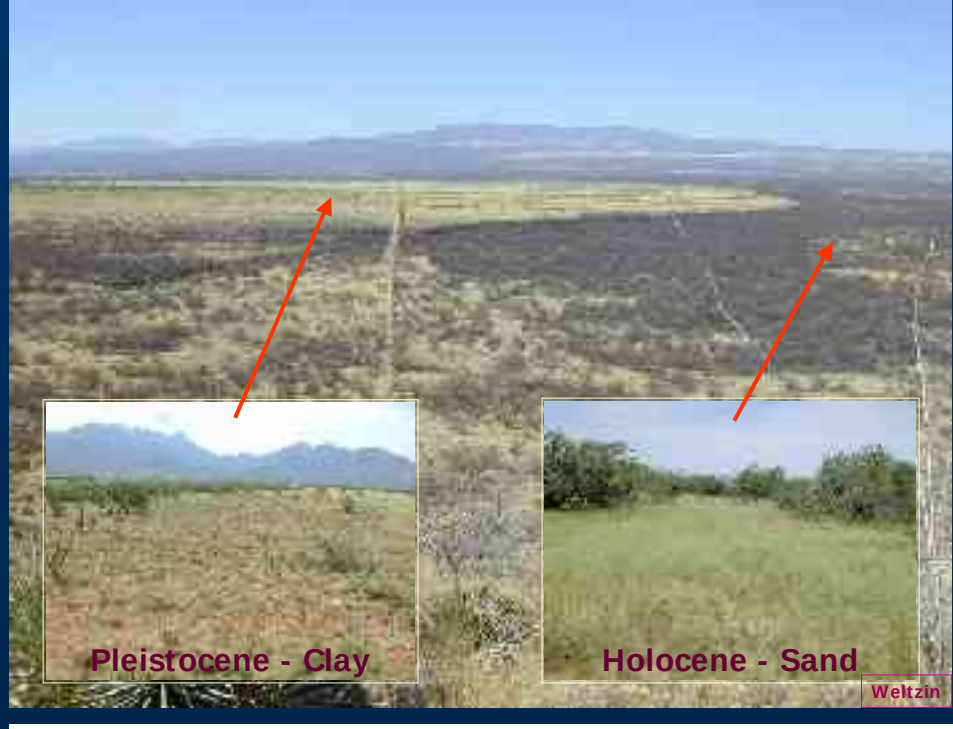
CO_2 efflux controls the response of ecosystem C exchange in response to precipitation pulses



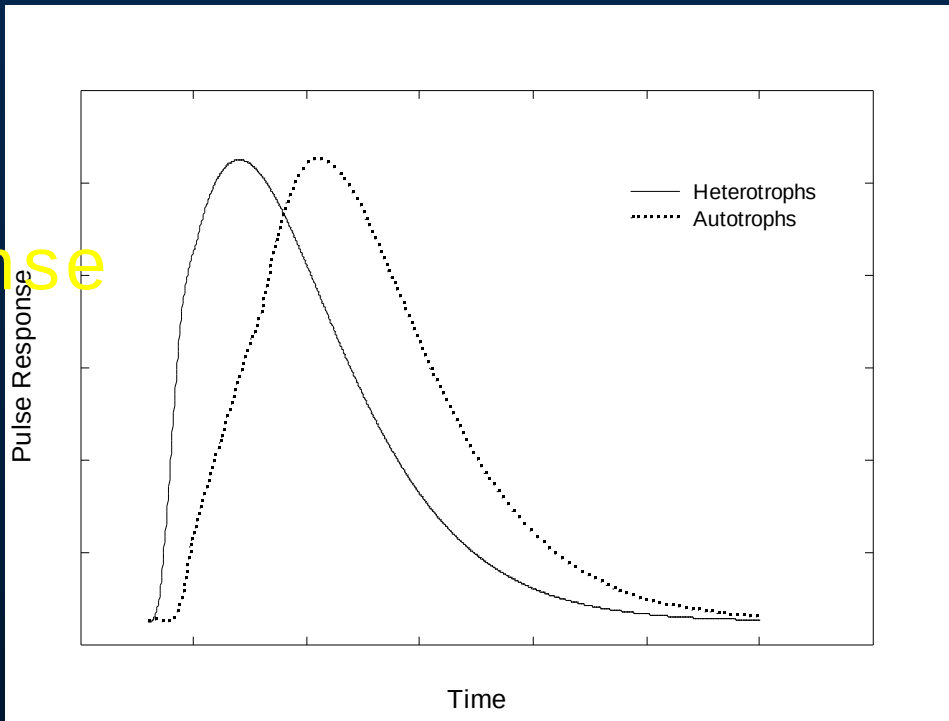
Differences between ecosystem response to pulse size is related to the duration of activity of different processes, not the maximum activity of those processes

Controls on efflux

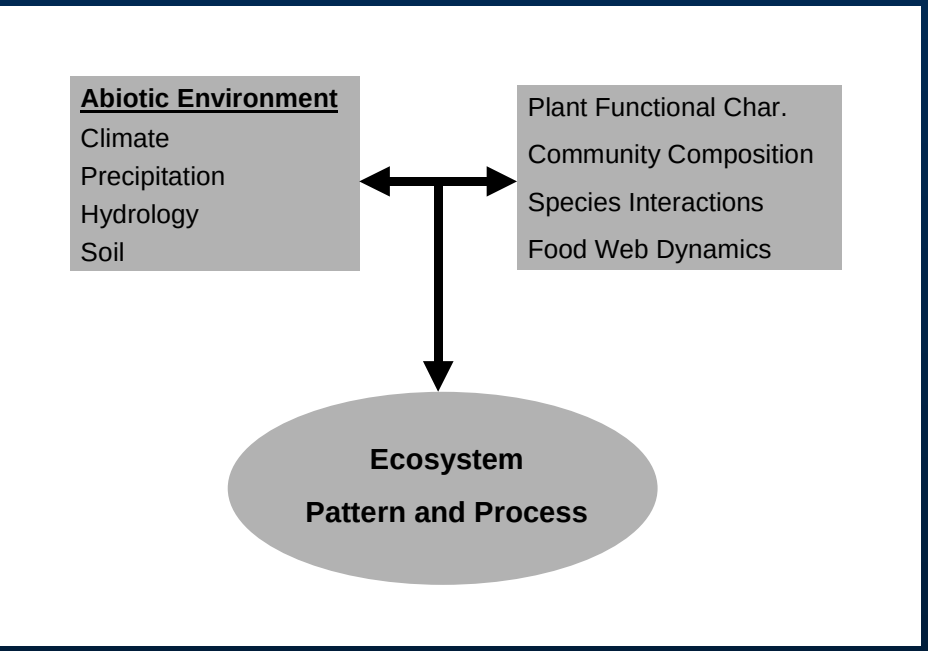
Soil characteristics

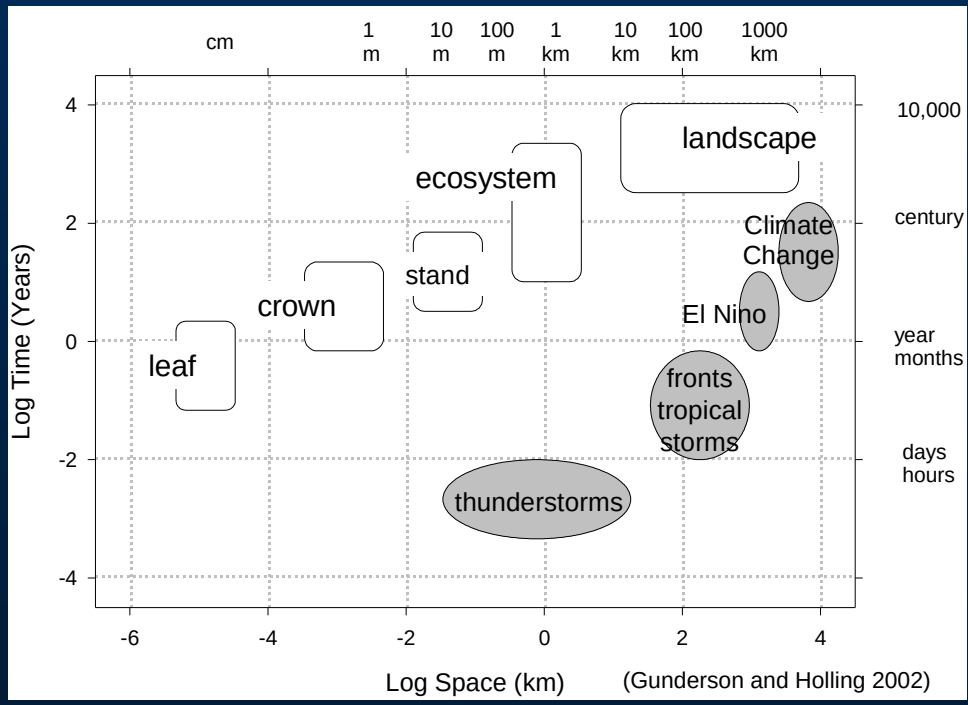


Soil heterotrophic response



Research across many scales that will allow us to build understanding of ecological patterns and process in space and time in these semi-arid ecosystems





Acknowledgements

Huxman Lab
- Greg Barron-Gafford
- Jessie Cable
- Alex Eilts
- Danielle Ignace
- Mike Mason
- Dan Potts
- Anna Tyler

Russell Scott

Bill Cable

Dave Williams

Jake Weltzin

Enrico Yepez

SAHRA, NSF, IALC, USDA, University of Arizona

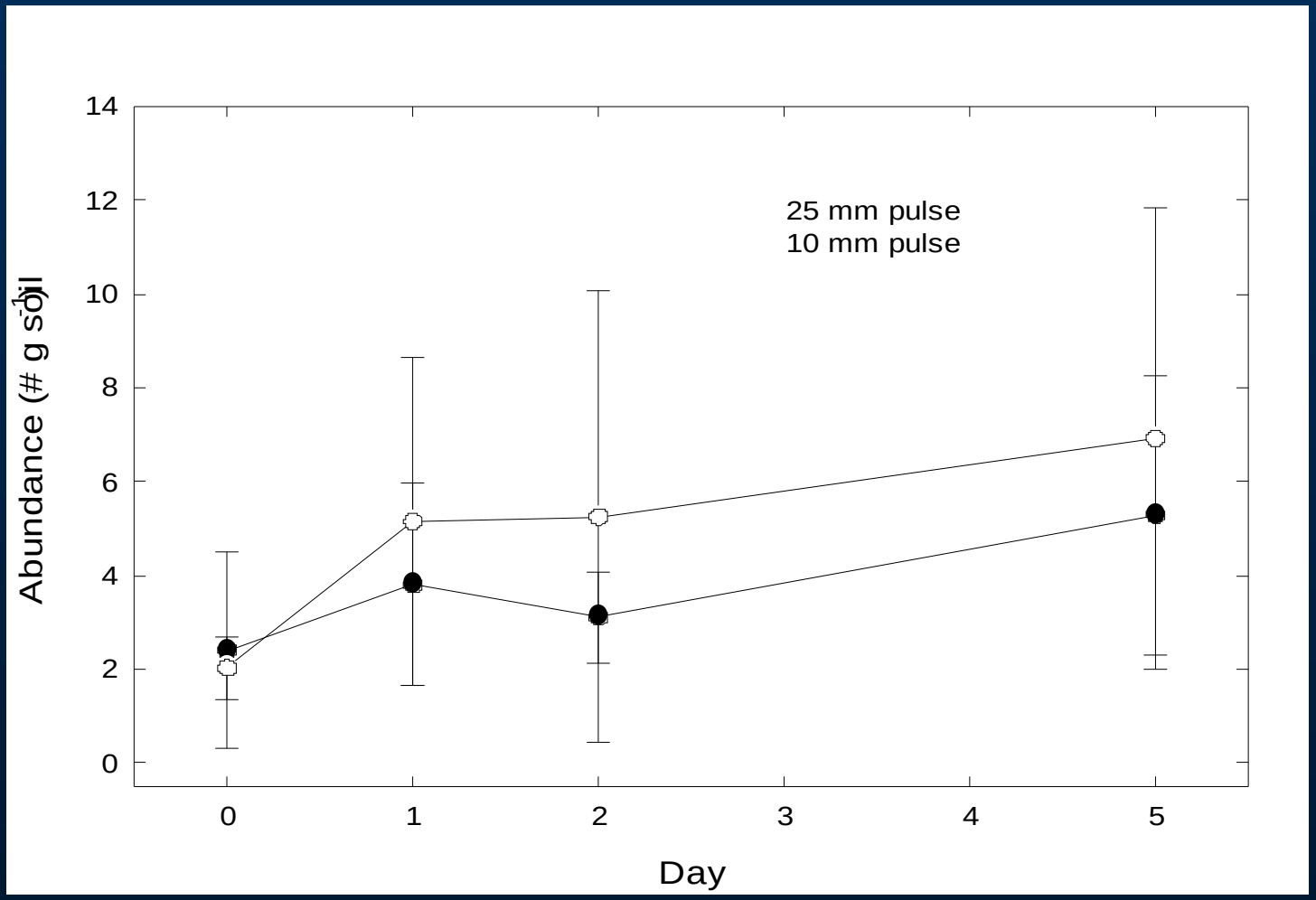
San Pedro River Basin

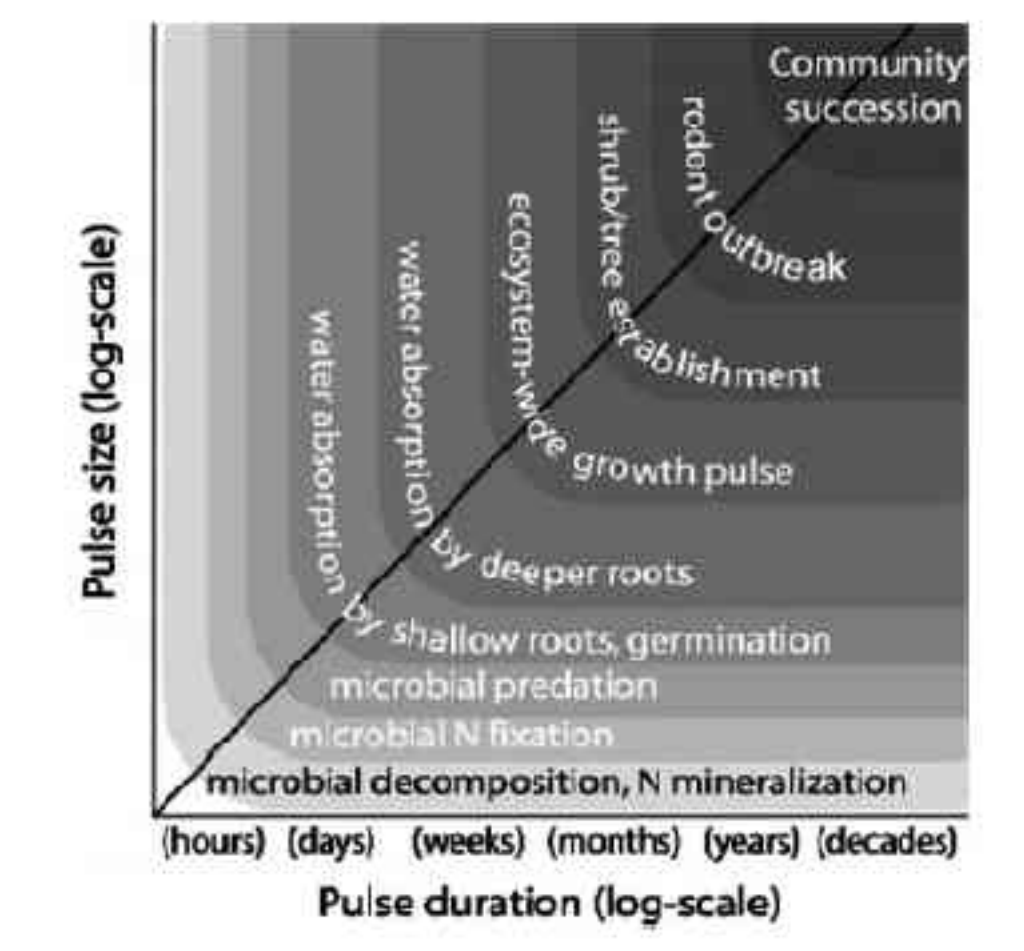
Historic grassland

Historic grassland with developing mesquite

Fully developed mesquite bosque

Soil nematode abundance increases with pulse



What is the role of quantitative biology?

It is the interdisciplinary interactions that will allow us to build knowledge in these non- equilibrium systems