

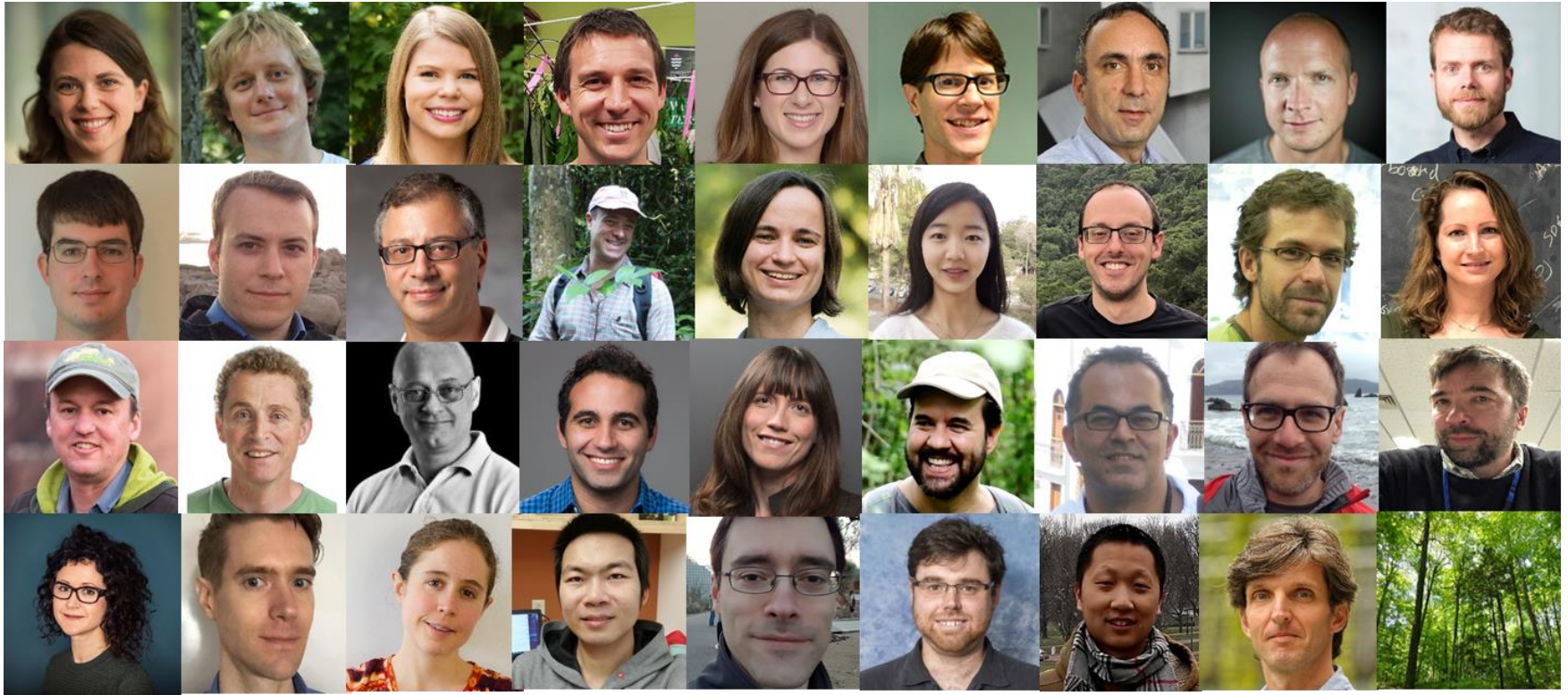
# Detecting forest response to droughts with microwave observations of vegetation water content

Alexandra Konings (Stanford University)

with

Sassan Saatchi, Christian Frankenberg, Michael Keller, Victor Leshyk, William Anderegg, Vincent Humphrey, Ashley Matheny, Anna Trugman, Lawren Sack, Elizabeth Agee, Mallory Barnes, Oliver Binks, Kerry Cawse-Nicholson, Bradley Christoffersen, Dara Entekhabi, Pierre Gentine, Nataniel Holtzman, Gabriel Katul, Yanlan Liu, Marcos Longo, Jordi Martinez-Vilalta, Nate McDowell, Patrick Meir, Maurizio Mencuccini, Assaad Mrad, Kimberly Novick, Rafael Oliveria, Paul Siqueira, Susan Steele-Dunne, David Thompson, Yujie Wang, Richard Wehr, Jeffrey Wood, Xiangtao Xu, Pieter Zuidema

# Credit to attendees of Keck Institute workshops



First workshop October 14-18, 2019

Second workshop (this talk): October 26-30, 2020

# VWC is informative about many processes

Transpiration &  
root water uptake

Phenology

Disturbance: fire,  
mortality, etc.

Influence of  
drought on all the  
above



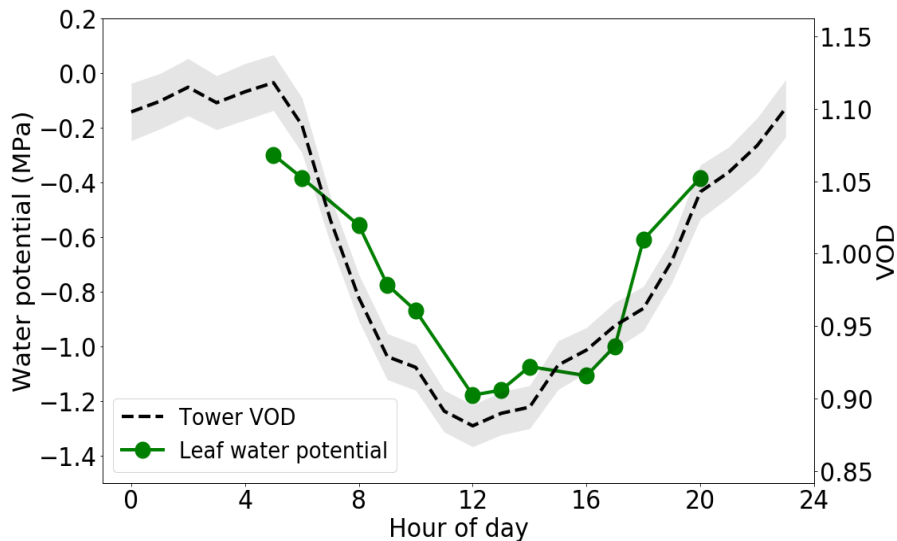
# VWC responds to both biomass and water stress

VOD & backscatter sensitive to VWC

VWC = relative water content (RWC) x aboveground biomass

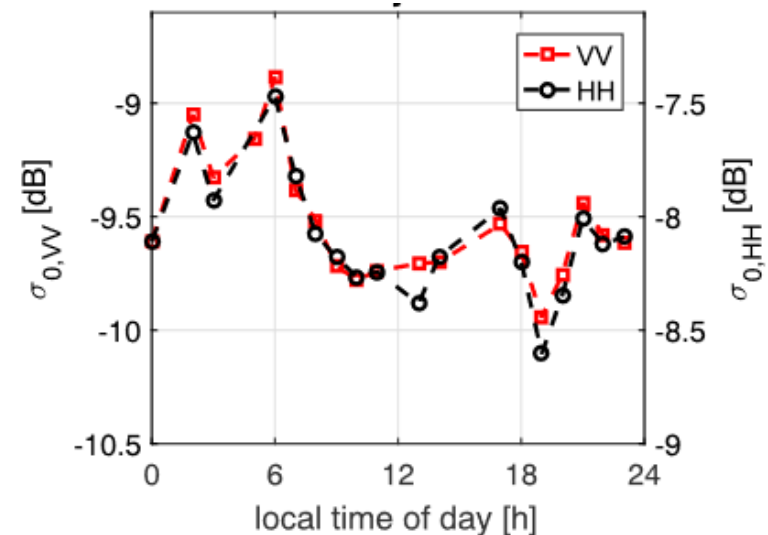
RWC changes is non-trivial, as observed in diel cycle

L-band radiometer on tower



*Holtzman et al, BG, 2021*

Ku-band RapidScat sensor on ISS



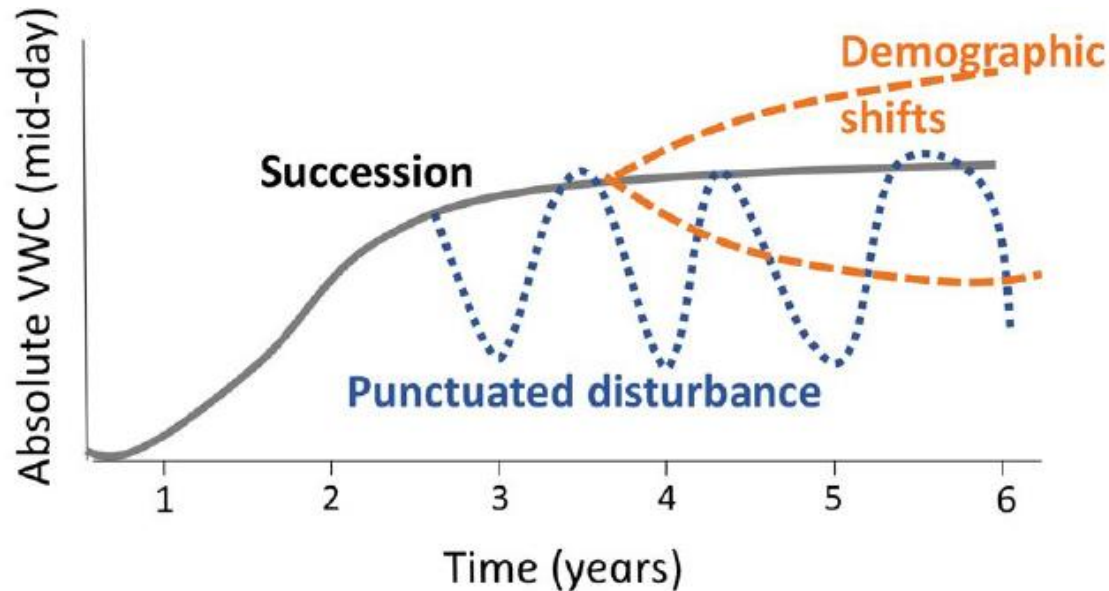
*van Emmerik et al, GRL, 2017*

# How to isolate different processes?

*Consider different timescales!*

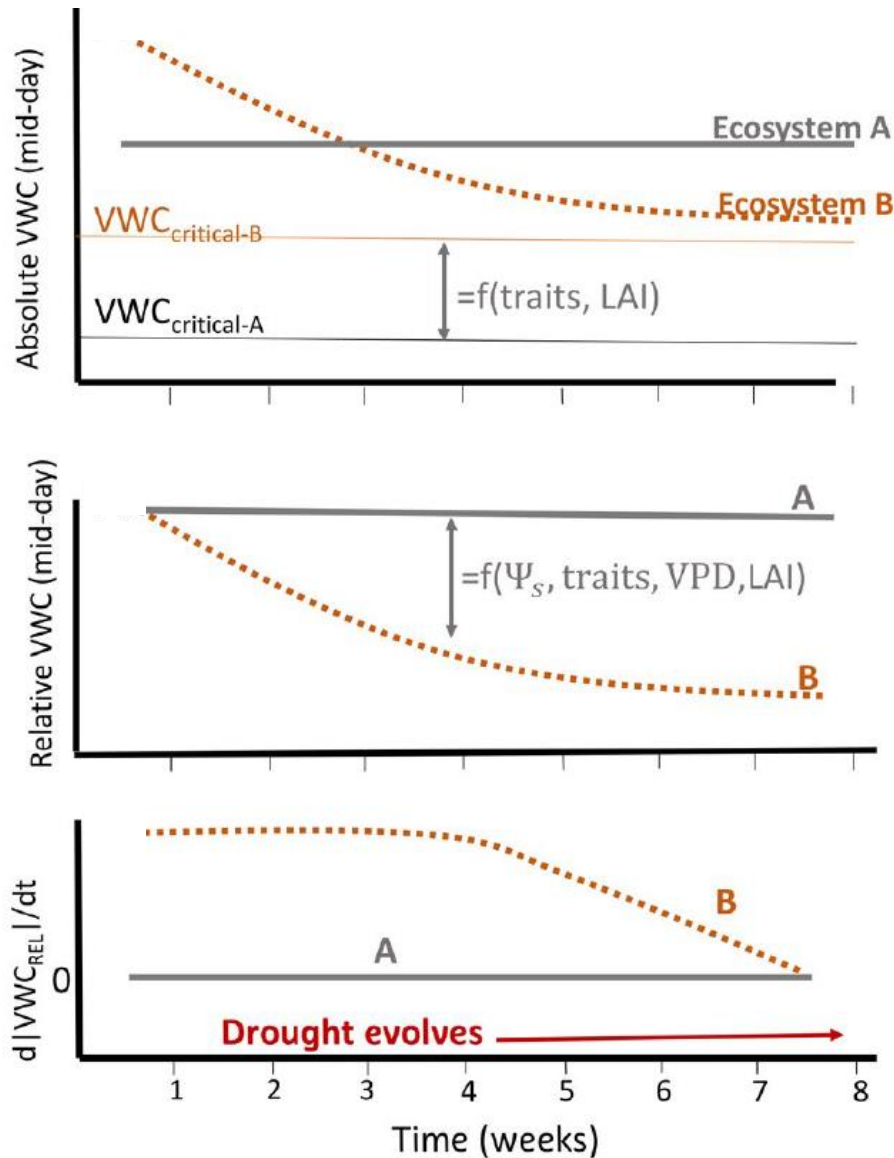


# Biomass & structure most relevant at long timescales



Multi-year and decadal timescales of variation are relevant for studies of disturbance, land-use dynamics, succession, etc...

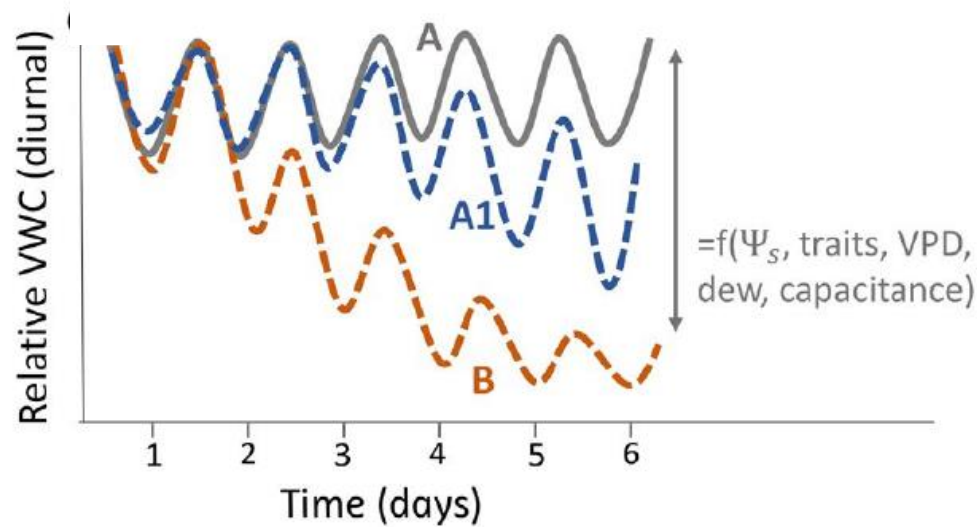
# Multi-week patterns reflect progressive dehydration



Must account for possible LAI changes

Slope of RWC with time may provide measure of community-level drought resistance and resilience

# Diel variations reflect plant hydraulics



Diel cycles is balance of transpiration, root water uptake, and redistribution of water across tree

Variations in diel cycle with time reflect root, stomatal, and xylem responses to changing hydrometeorology

Because reflects root water uptake, also indicative of belowground water access



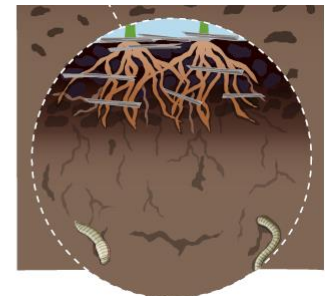
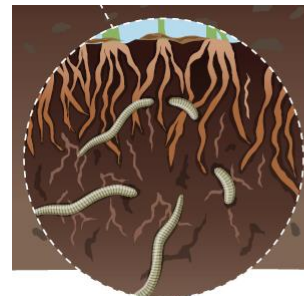
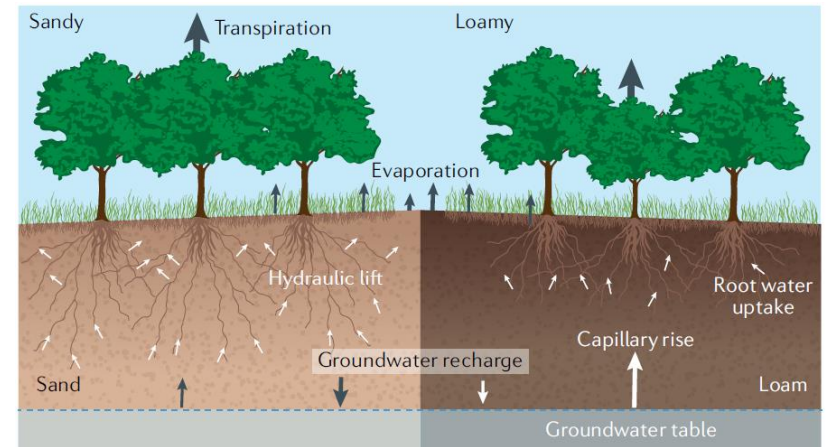
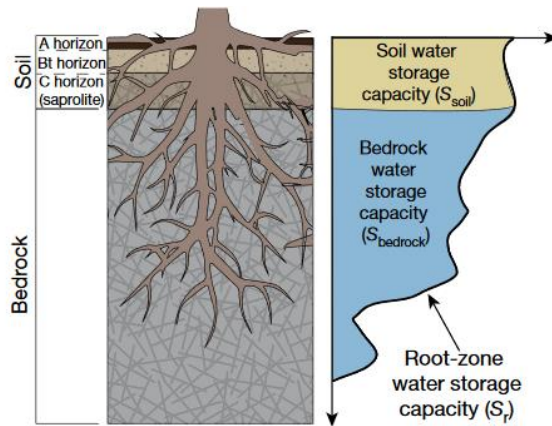
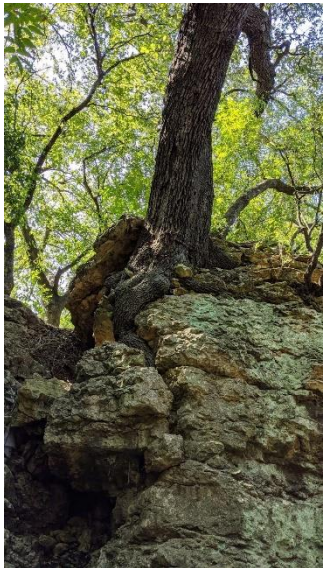
# Many open questions about root water uptake

Widespread rock moisture uptake?

When and where does hydraulic redistribution occur?

How do vegetation effects on soil structure feed back?

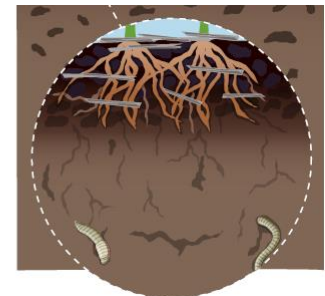
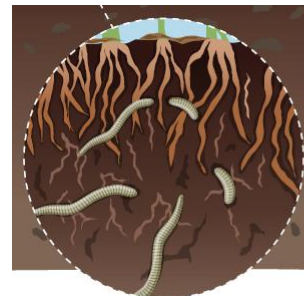
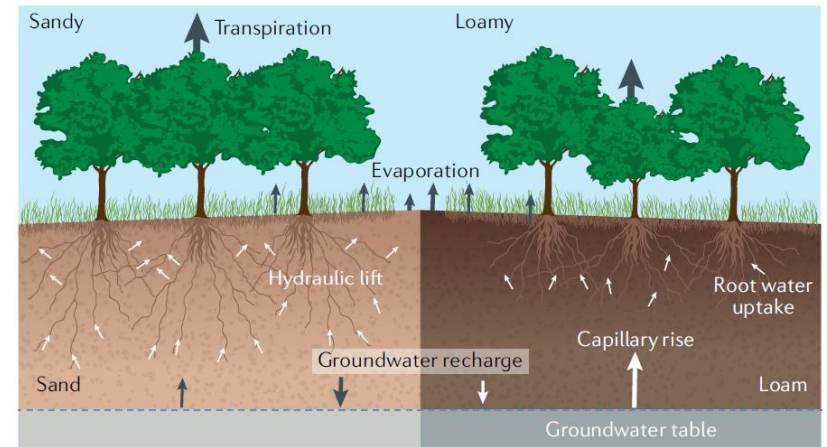
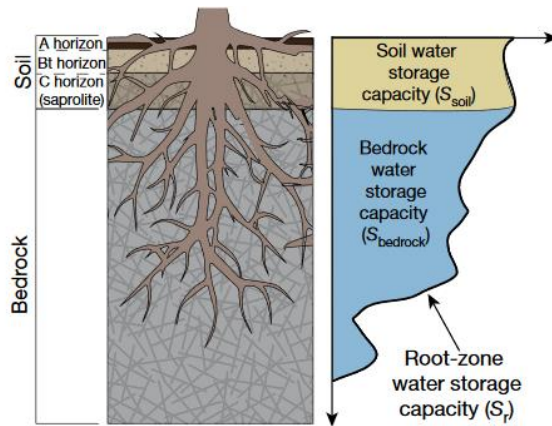
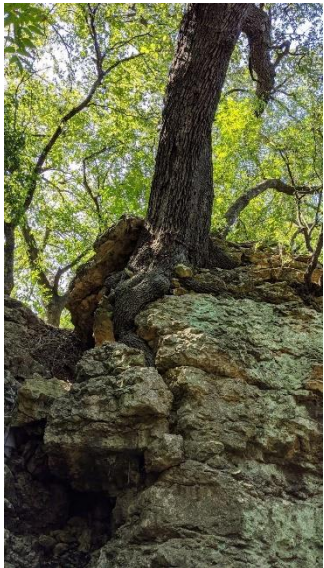
How to better account for uncertain soil water retention curves?



# Many open questions about root water uptake

Possible solution: can we infer belowground water uptake from aboveground RWC?

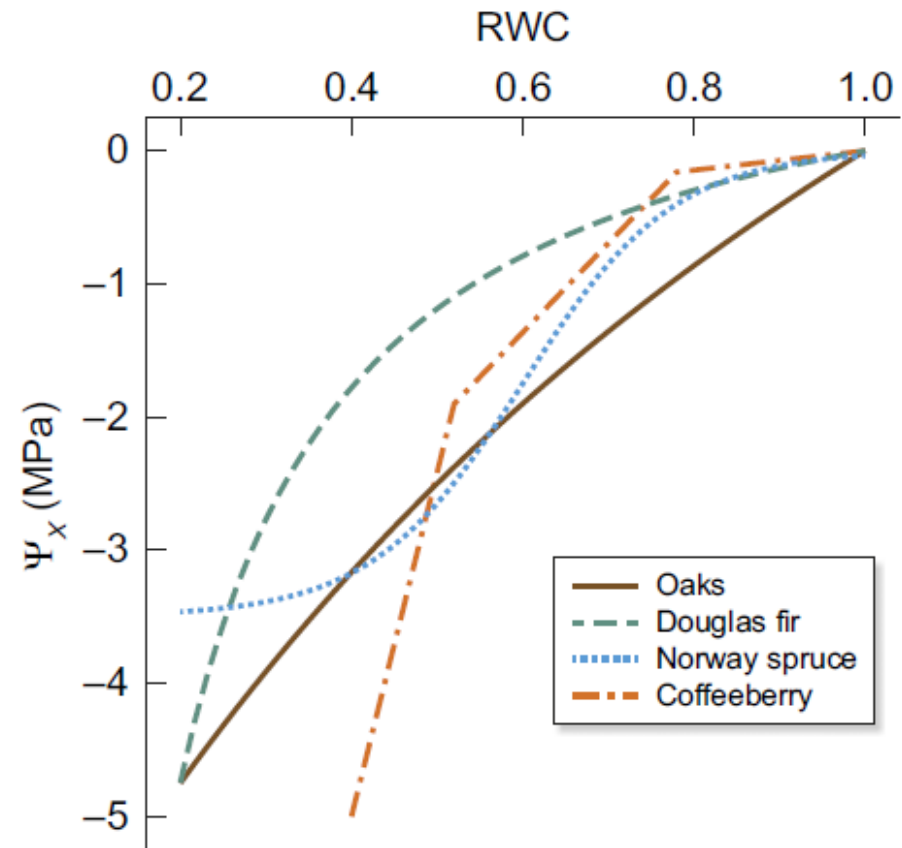
One option: combine data with models



# Links to water stress models often require $\Psi$

Plant hydraulics varies with water potential  $\Psi$ , not content.

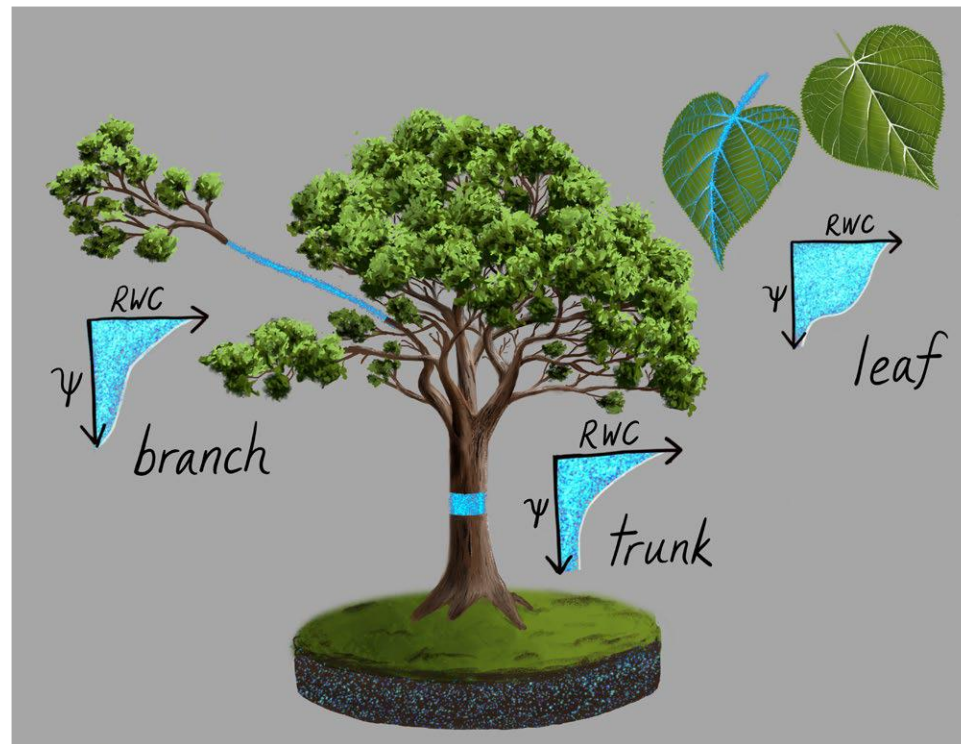
$\Psi$  well known to relate to RWC among plant physiologists – the “pressure-volume curve”



# Can this scale to whole-tree or ecosystem?

What would an ecosystem scale pressure-volume curve look like?

How does remotely sensed whole-canopy RWC relate to  $\Psi$  noting that  $\Psi$  varies with height, between trees, etc?

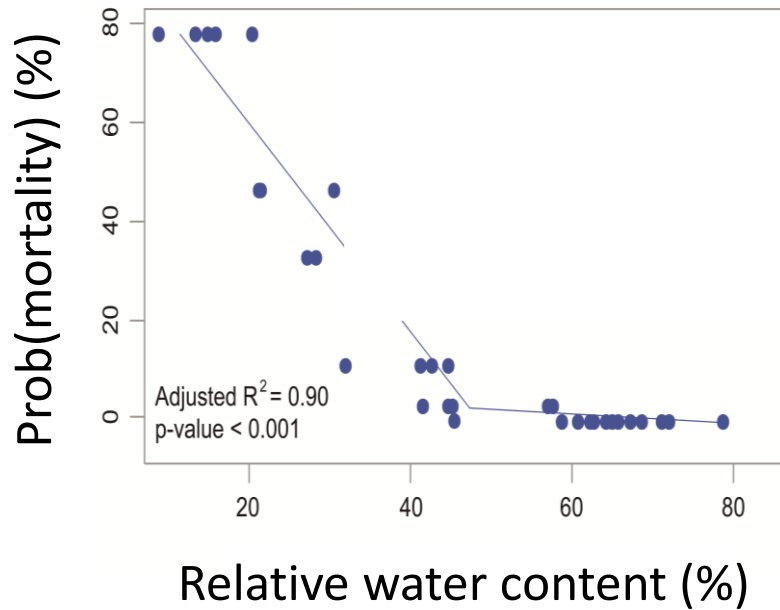


Plant hydraulic modelling exercises underway

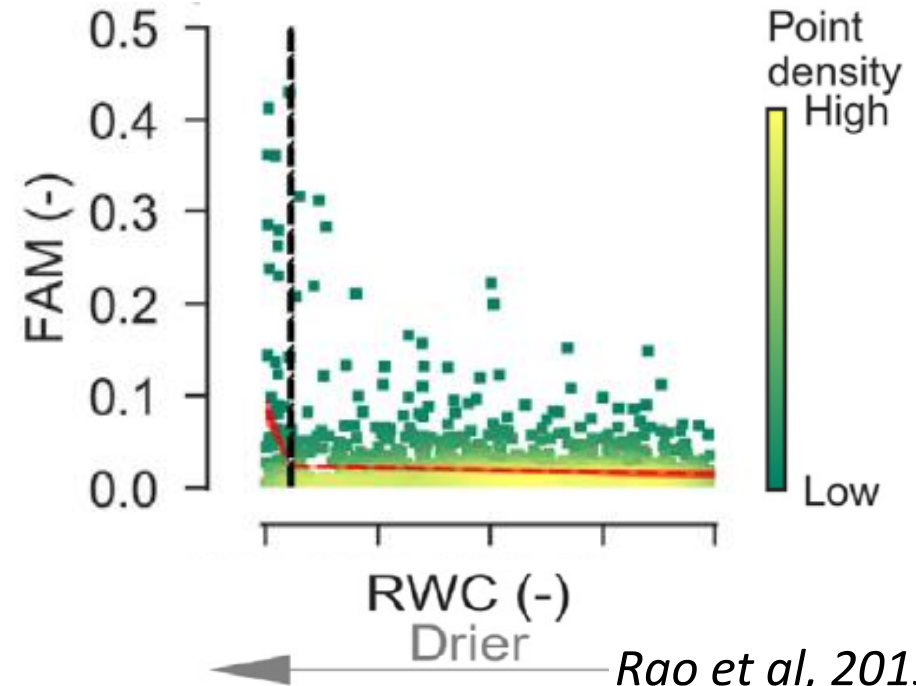
# RWC is useful even if not linked to $\Psi$ : mortality



### Greenhouse studies



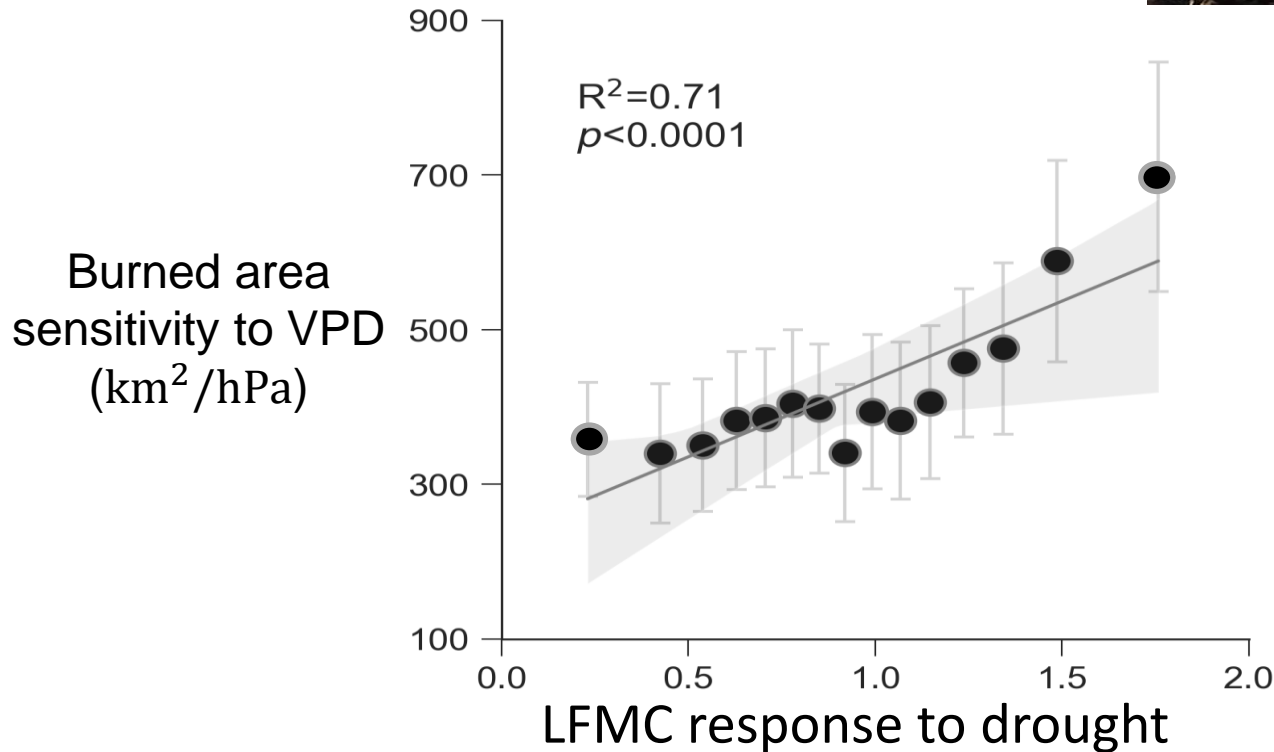
### Radiometry-derived RWC



# RWC is useful even if not linked to $\Psi$ : fire

Live fuel moisture content

$$LFMC = \frac{VWC}{AGB_{dry}} \times 100\%$$



# Remaining issues and opportunities

---



need for more/better validation data



need for improved retrieval algorithms

- effect of EM frequency?

- vegetation structure? dew?

-....

opportunities:

- can we separate different canopy components by combining sensors across frequencies?
- improved linking to optical/lidar/other remote sensing?

# ...but nevertheless, promising data source

Transpiration &  
root water uptake

Phenology

Disturbance: fire,  
mortality, etc.

Influence of water  
stress on all the  
above



**How do ecosystem carbon storage/fluxes respond  
to changing hydrometeorological conditions?**



# Thanks!

---