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Title: Vegetation under changing climate: What determines who survives?

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Intended for: Invited seminar talk at New Mexico State University

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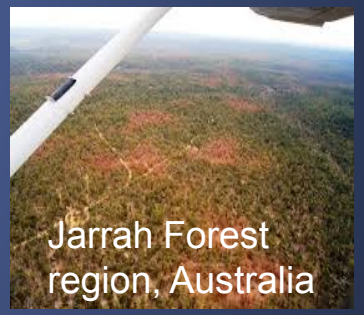

Vegetation under changing climate: What determines who survives?

Sanna Sevanto

Earth and Environmental Sciences Division

Nov. 9, 2018

LA-UR -

NNSA
National Nuclear Security Administration

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-EES and vegetation team
-Bioenergy and Biome Sciences
-Physics Division
-Material Sciences
-ISR

LANSCE LUJAN CENTER Los Alamos National Laboratory

LANSCE Los Alamos Neutron Science Center

UNM Pockman and Hanson groups

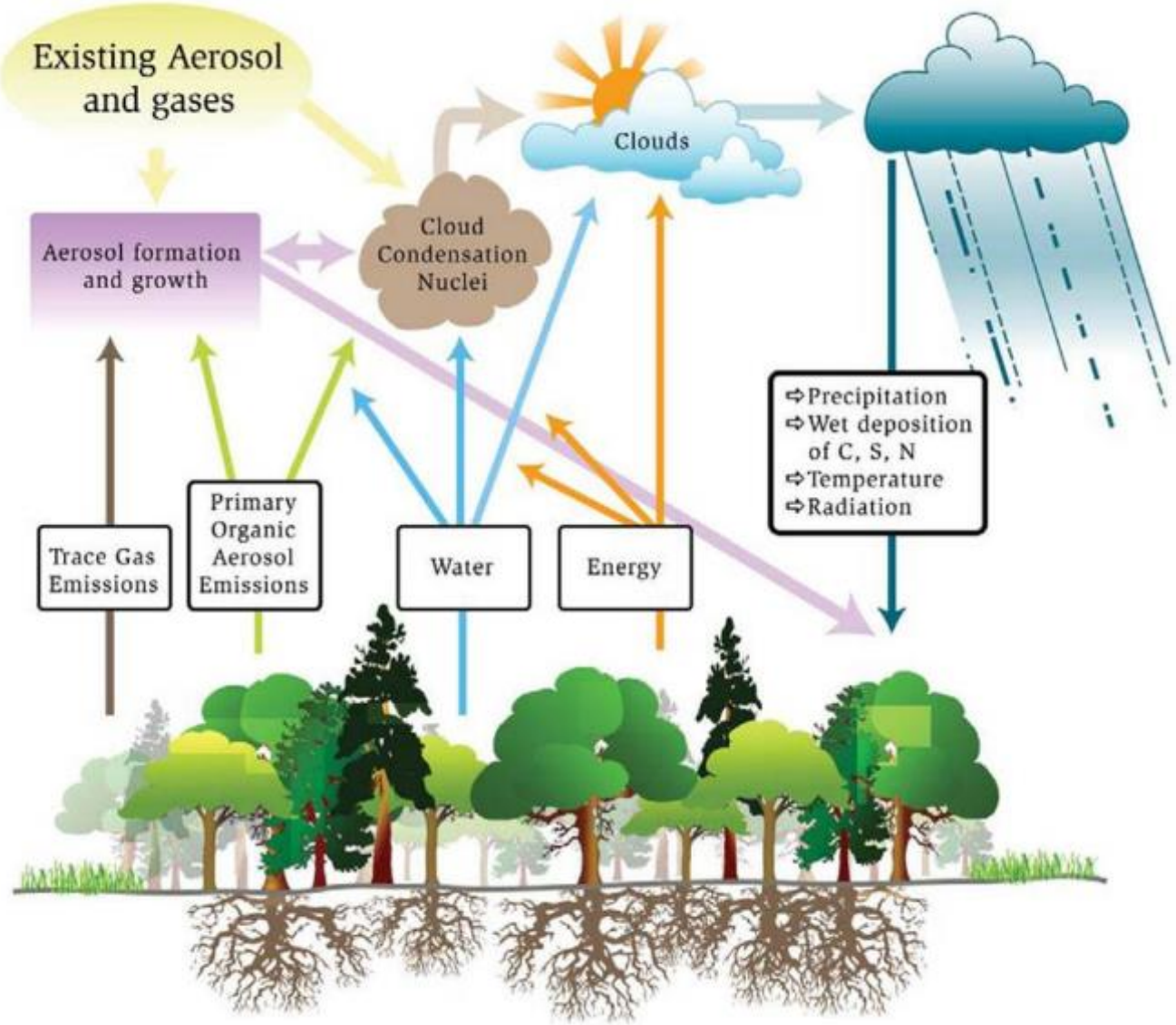
EMPA –Swiss Federal Laboratories of Materials Science

Dominique Derome, Jan Carmeliet, Thijs Defraeye, Alessandra Patera, David Mannes, David Habitur, Anne Bonnin @ Paul Scherrer Institute

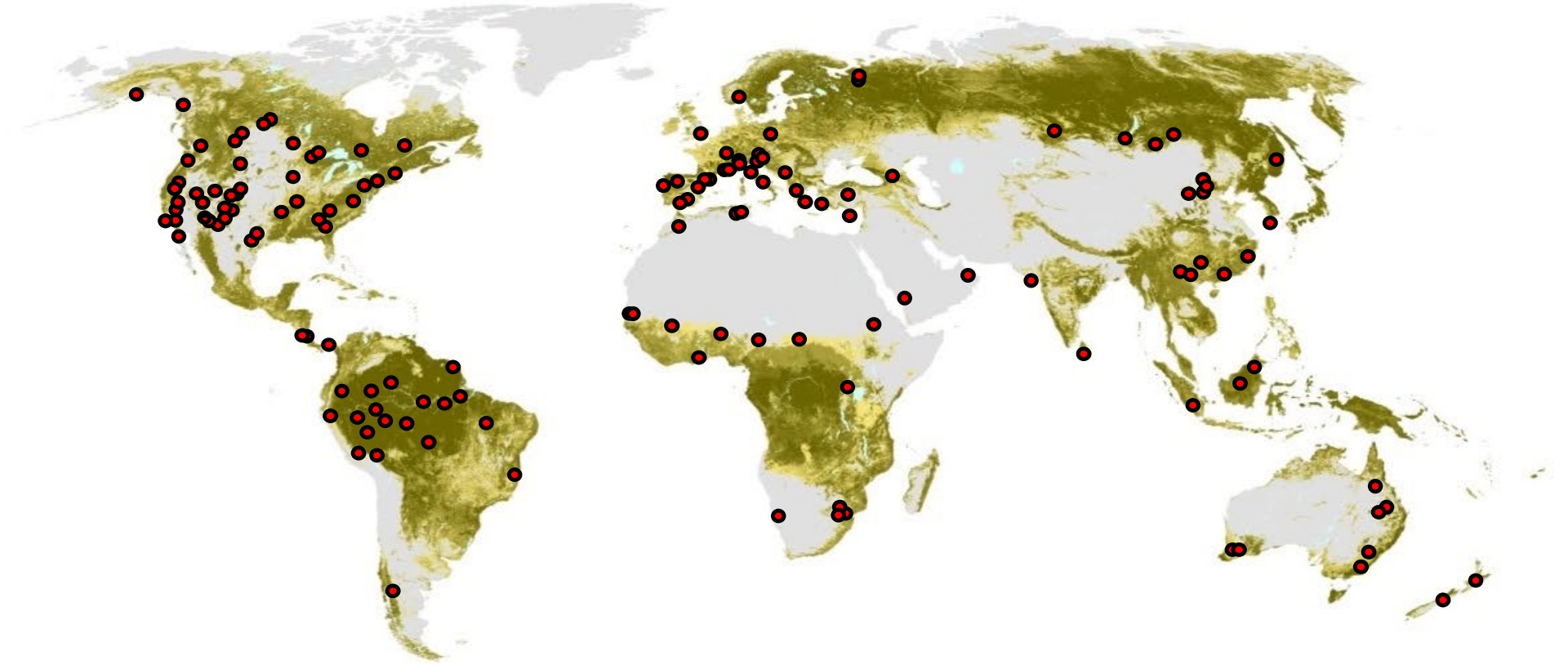
U.S. DEPARTMENT OF ENERGY

NSF

Forests are important for keeping the planet in balance

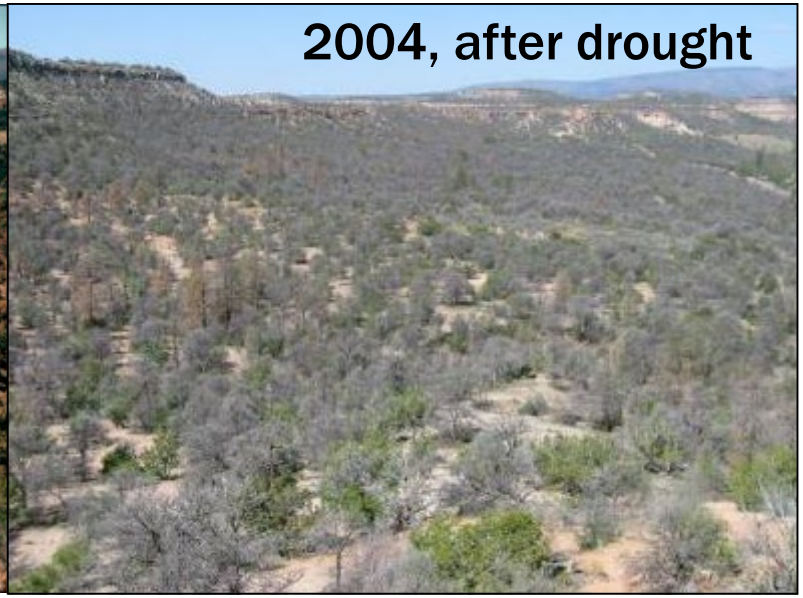


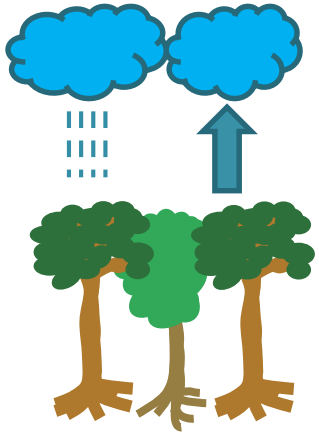
Motivation: Large-scale forest mortality events a are global phenomenon

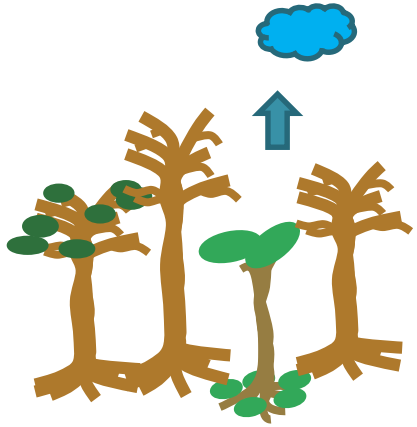


Allen, Breshears & McDowell 2015

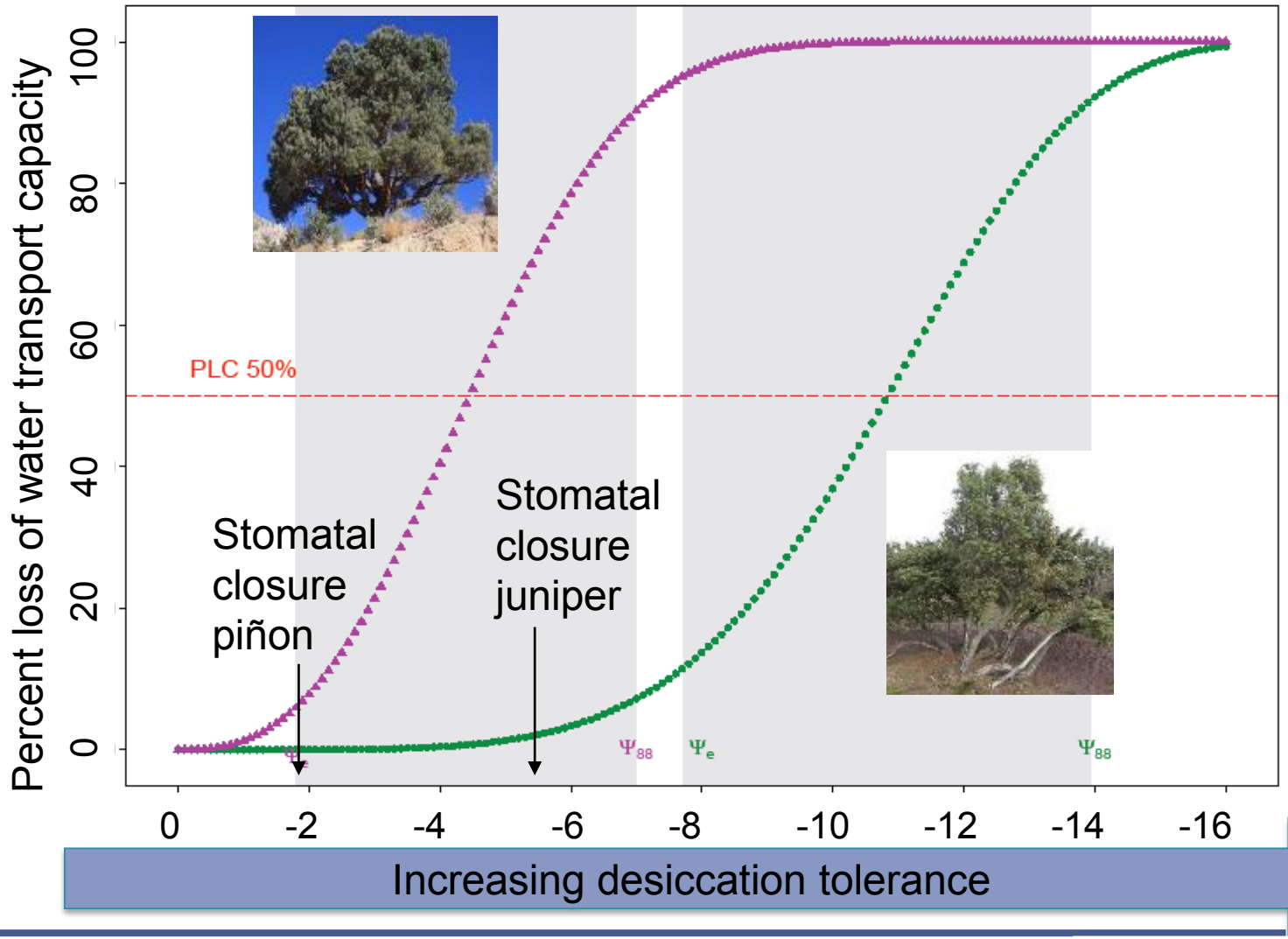
Green biomass increases precipitation



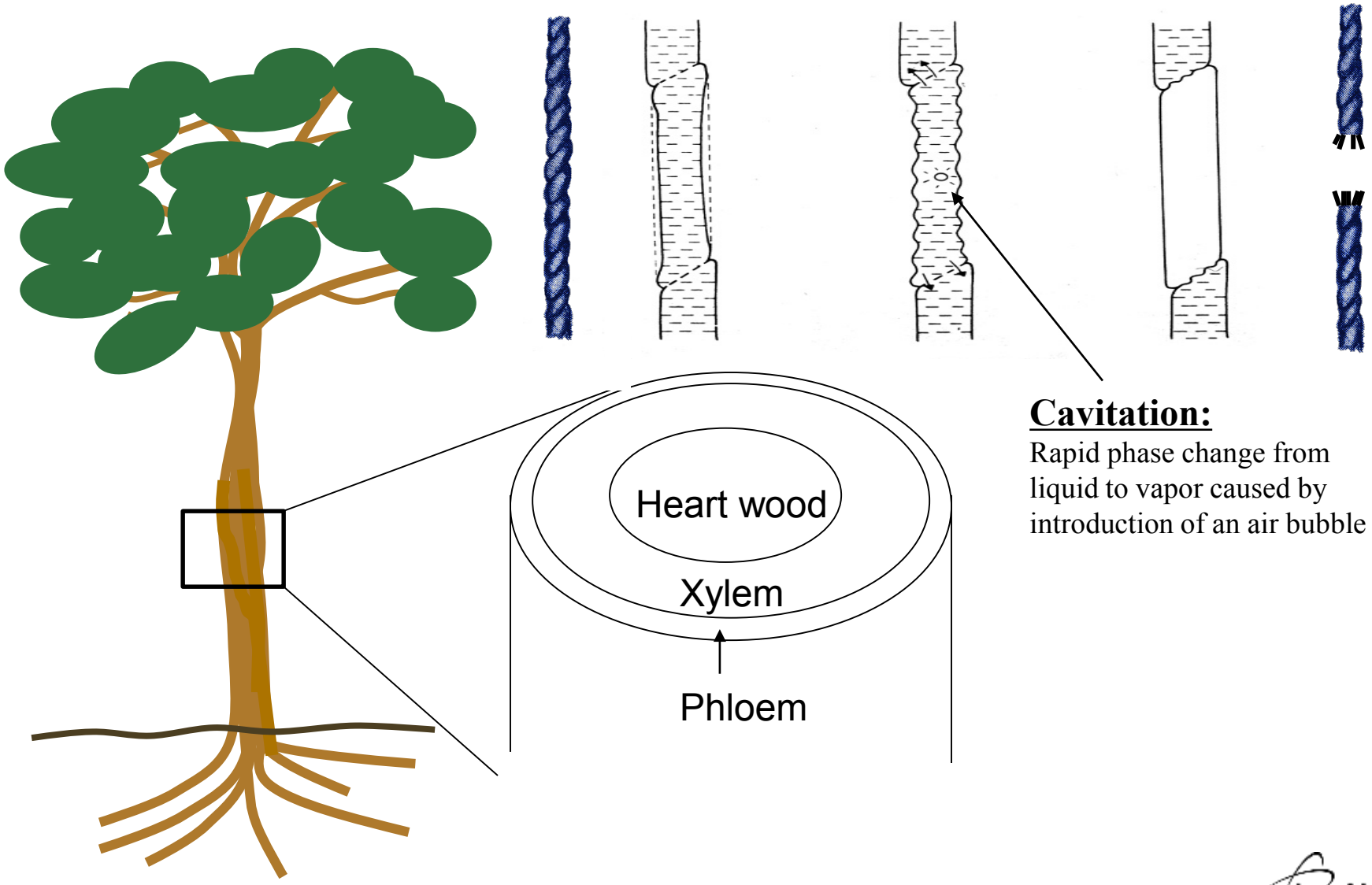




Different desiccation tolerance of pine and juniper makes PJ very interesting:



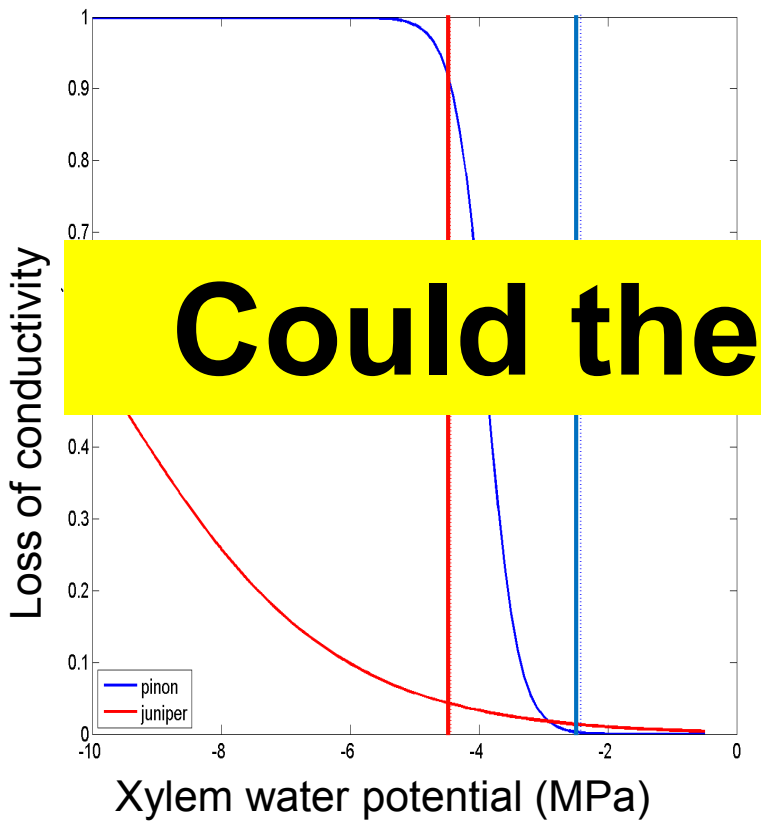
Basics of water flow in trees



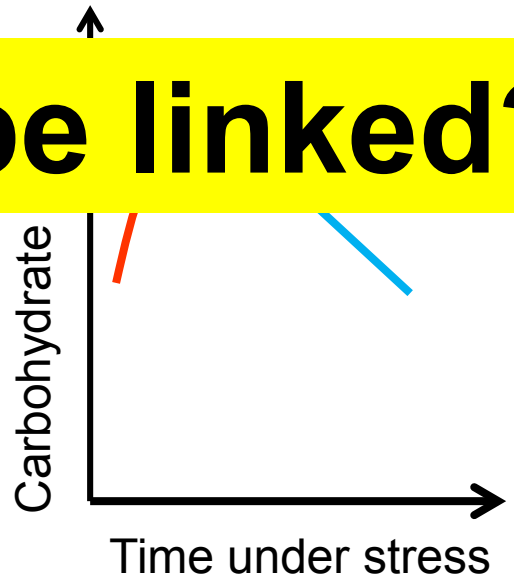
Cavitation:
Rapid phase change from liquid to vapor caused by introduction of an air bubble

Hypothesized mortality mechanisms

Hydraulic failure:



Carbon starvation:



Could these be linked?

McDowell et al. 2008, New Phytologist

How species avoid mortality?

Trees can respond to climate change by:

Adaptation 50-5000 years

Migration 60-250 m yr^{-1}

Acclimation

Acclimation to drought and warming

Acclimation to drought

Thicker and shorter needles

Growing deeper roots

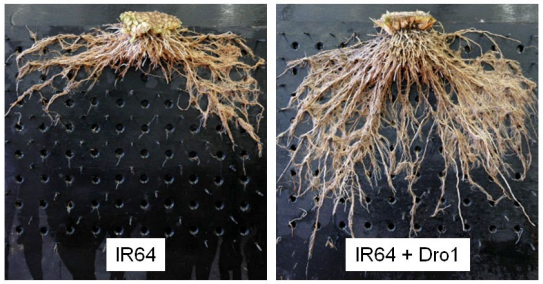
Acclimation to warming

Advanced phenology

Higher productivity

Acclimation to drought + warming

?



Tree SUrvival and MOrtality experiment: New Mexico in 2100

Temperature	Precipitation: Ambient P	Precipitation: Drought
Ambient T		
~+5°C		
Ambient T Chamber		

SUMO Forest SUrvival & MOrtality Understanding & Prediction

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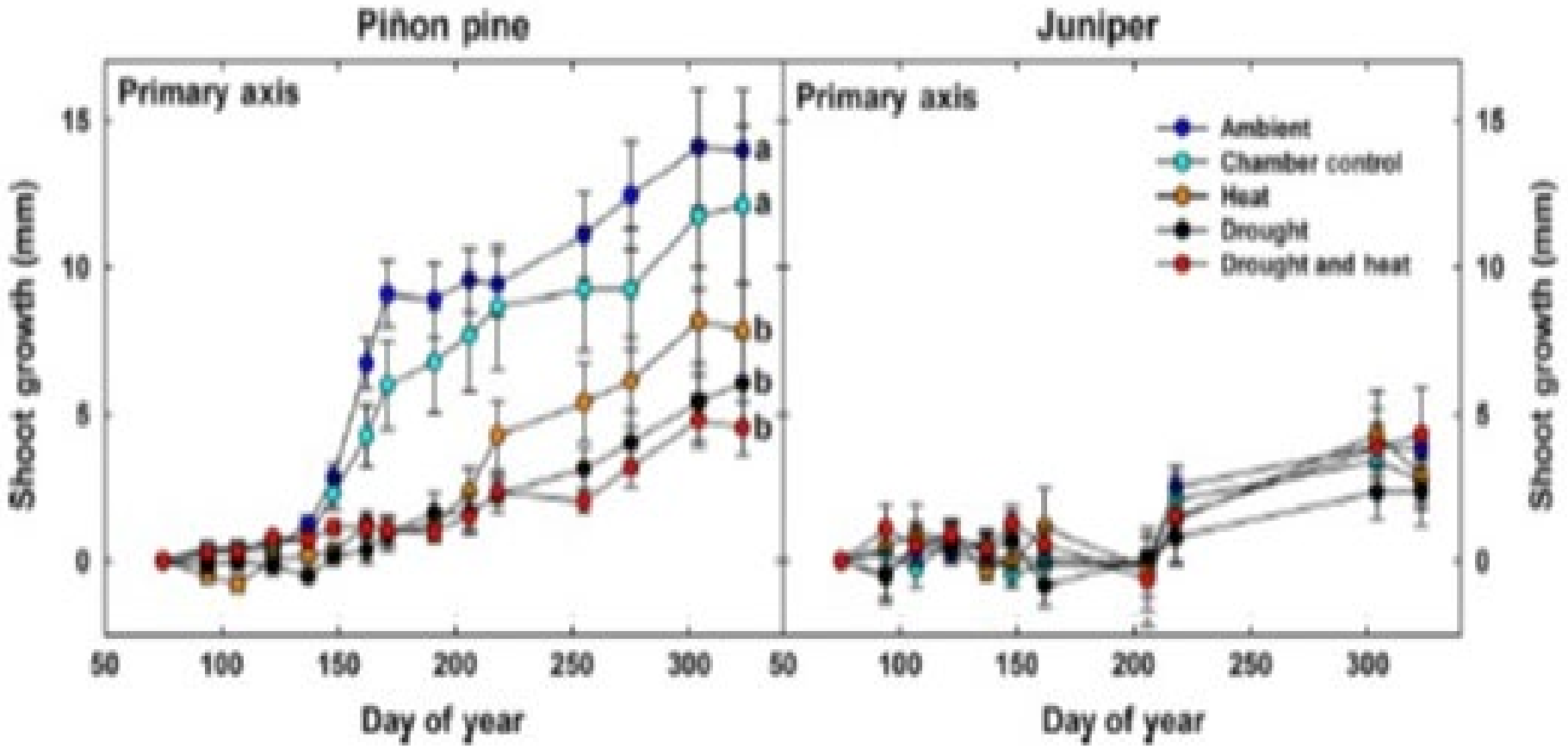
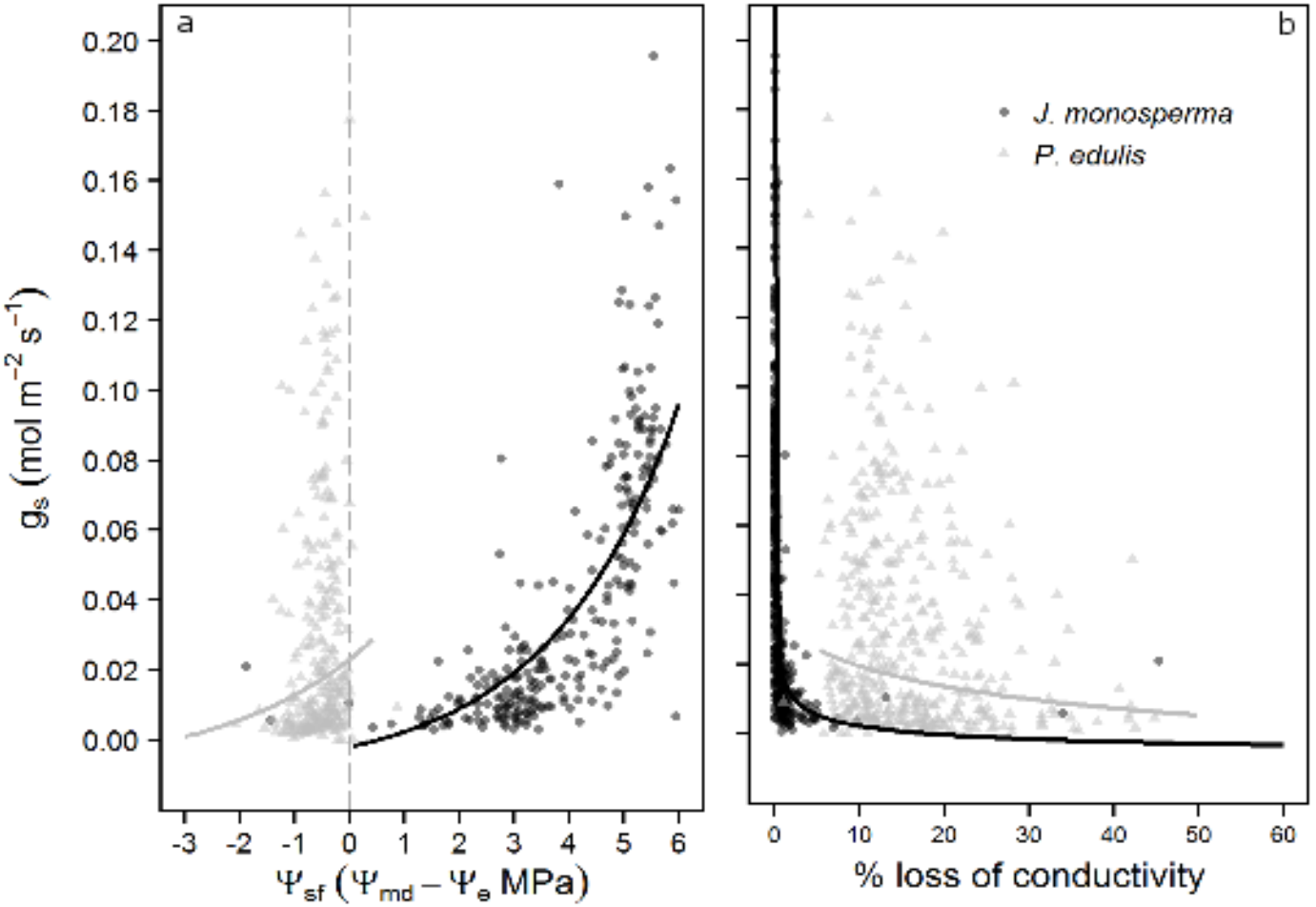
Moisture drives growth; Growth = health



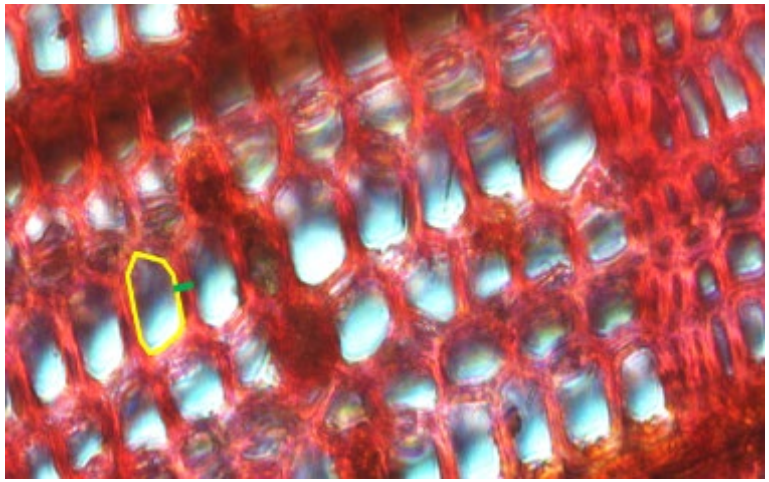
Adams et al. 2015 Global Change Biology

Mortality mechanisms: Hydraulic failure

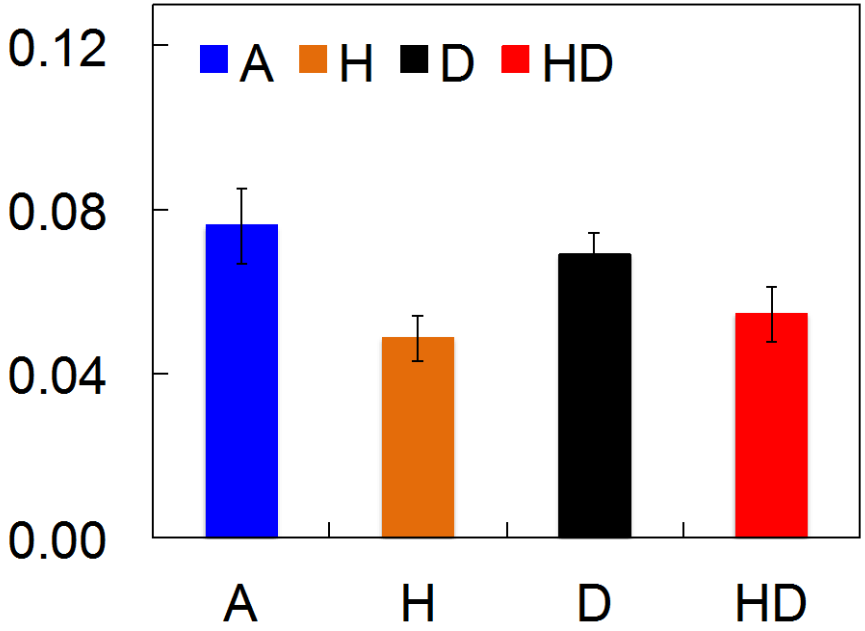


Garcia-Forner et al. 2016 PCE

Reduced hydraulic conductivity under warming

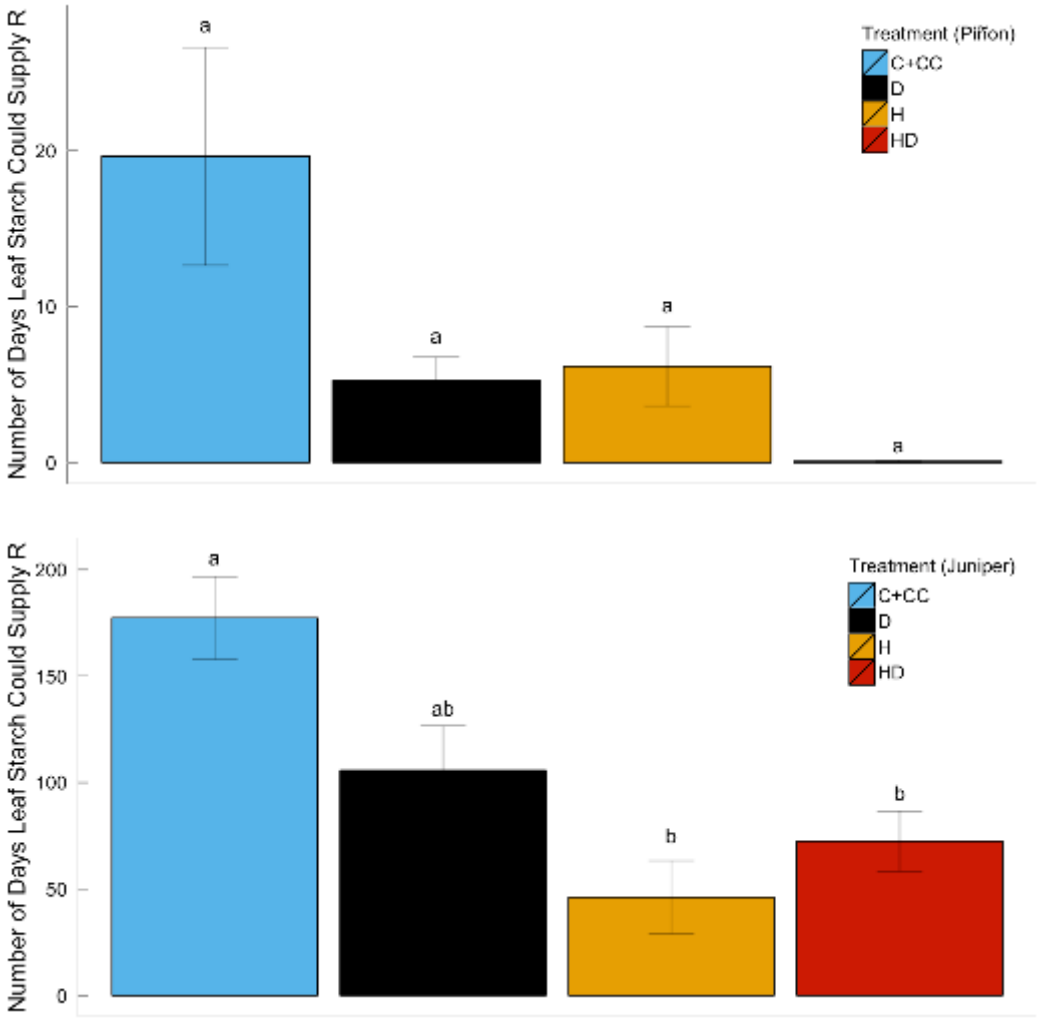


Early-wood tracheids from 2016 growth of a juniper tree (400x on a compound microscope)



Grossiord et al. 2017 PCE

How about carbon starvation?

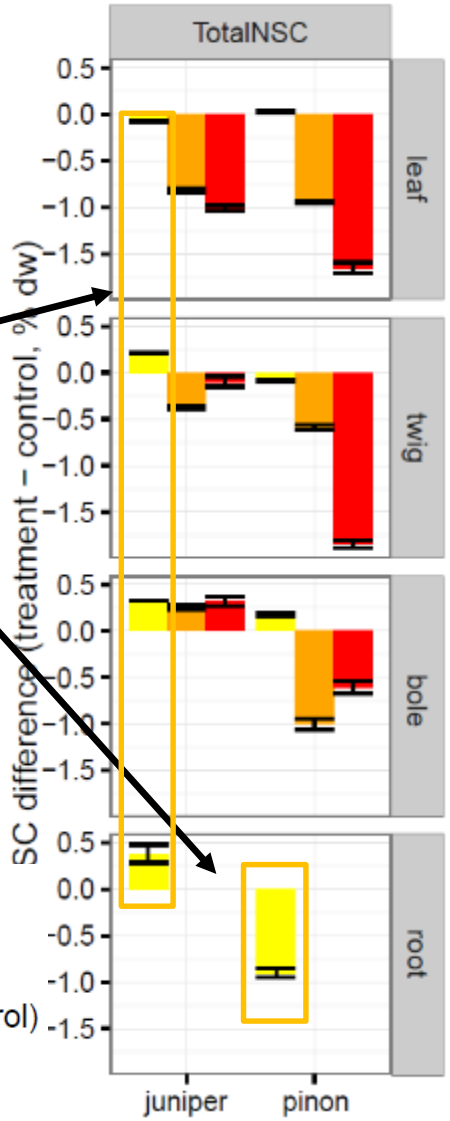


Changes in carbon storage

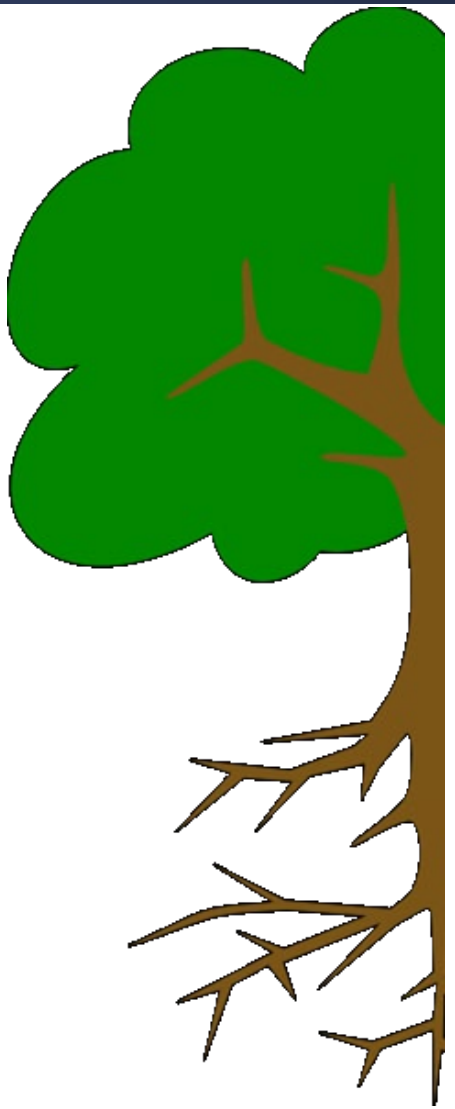
Drought:

juniper: increase whole-tree NSC

piñon: decrease root NSC



Drought - Ambient
Heat - (Chamber Control)
(Heat + Drought) - (Chamber Control)

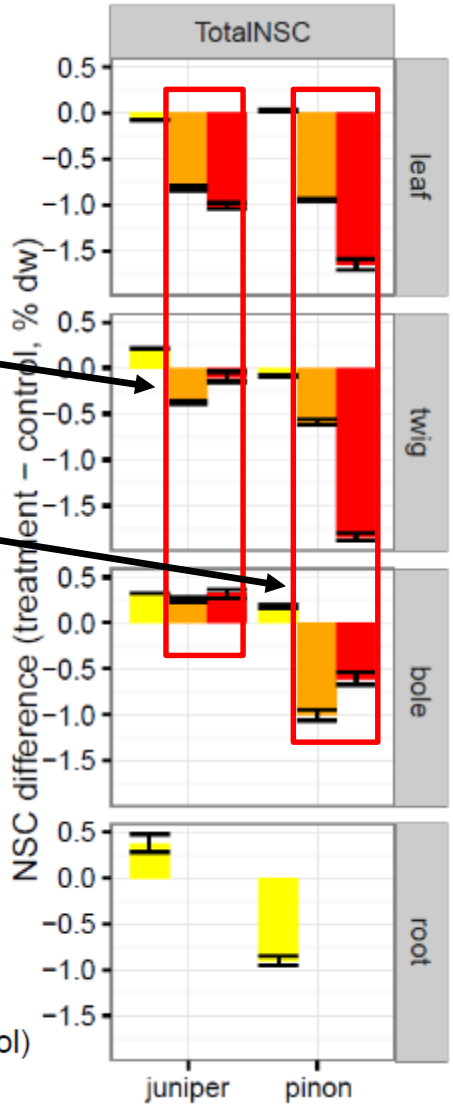


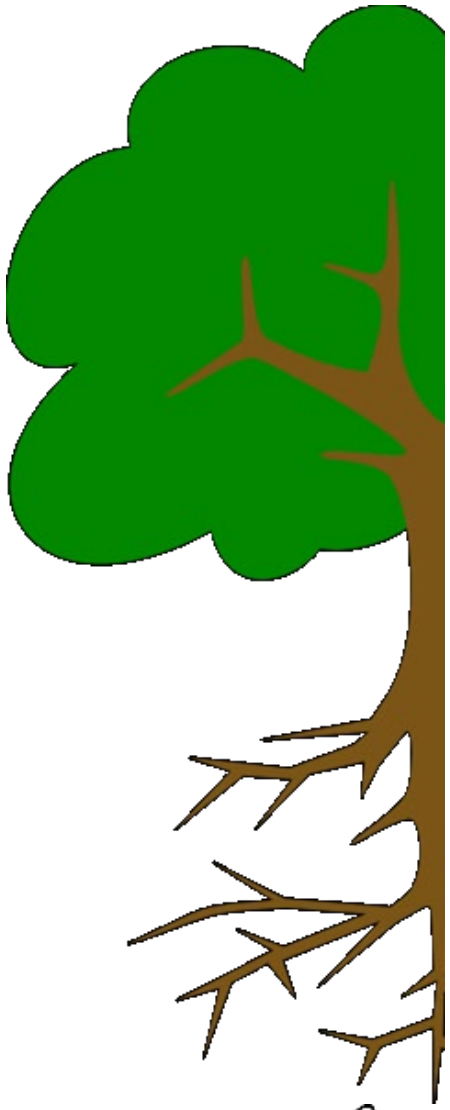
Changes in carbon storage

Heat & Heat + Drought:

juniper: shift allocation from canopy to stem

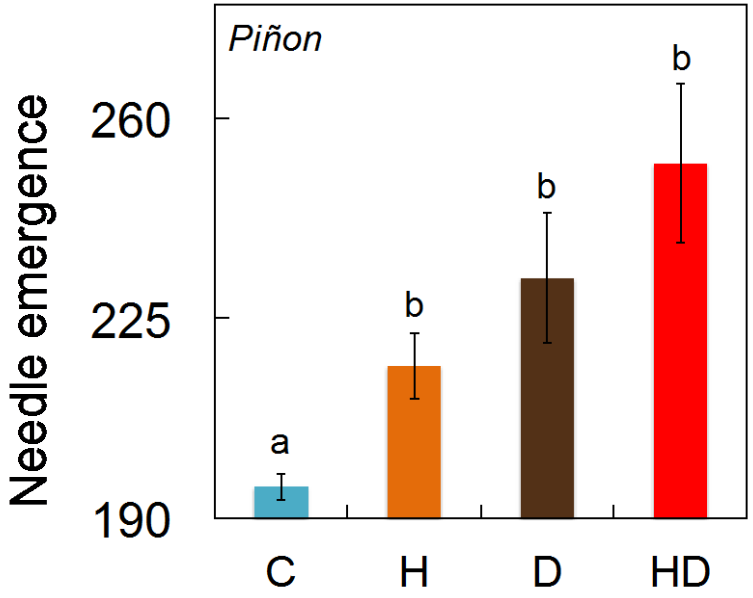
piñon: reduce whole-tree NSC



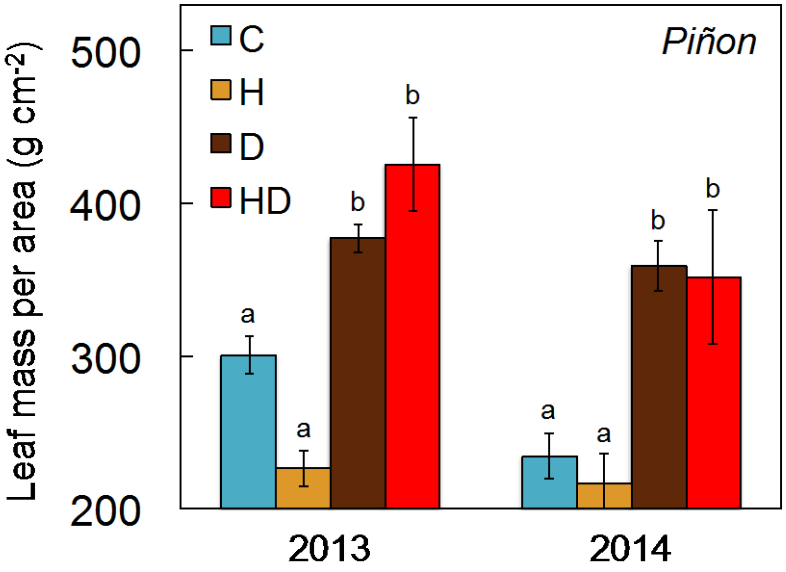


Acclimation: Phenology and foliar structure

Warming and drought induced delayed phenology



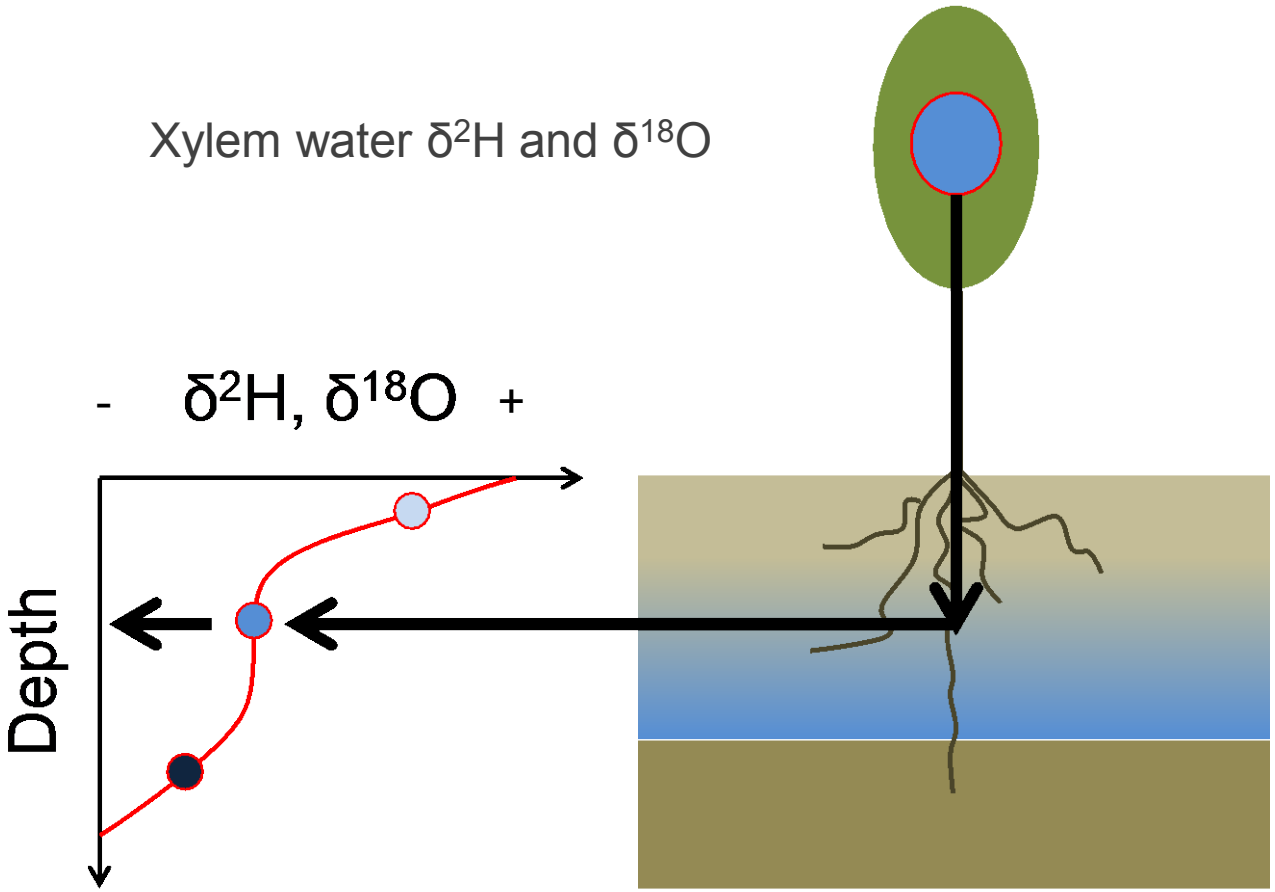
Drought reduced evaporative surfaces



Adams et al. 2015 GCB; Grossiord et al. 2017 JE

Acclimation of water uptake

Xylem water δ^2H and $\delta^{18}O$



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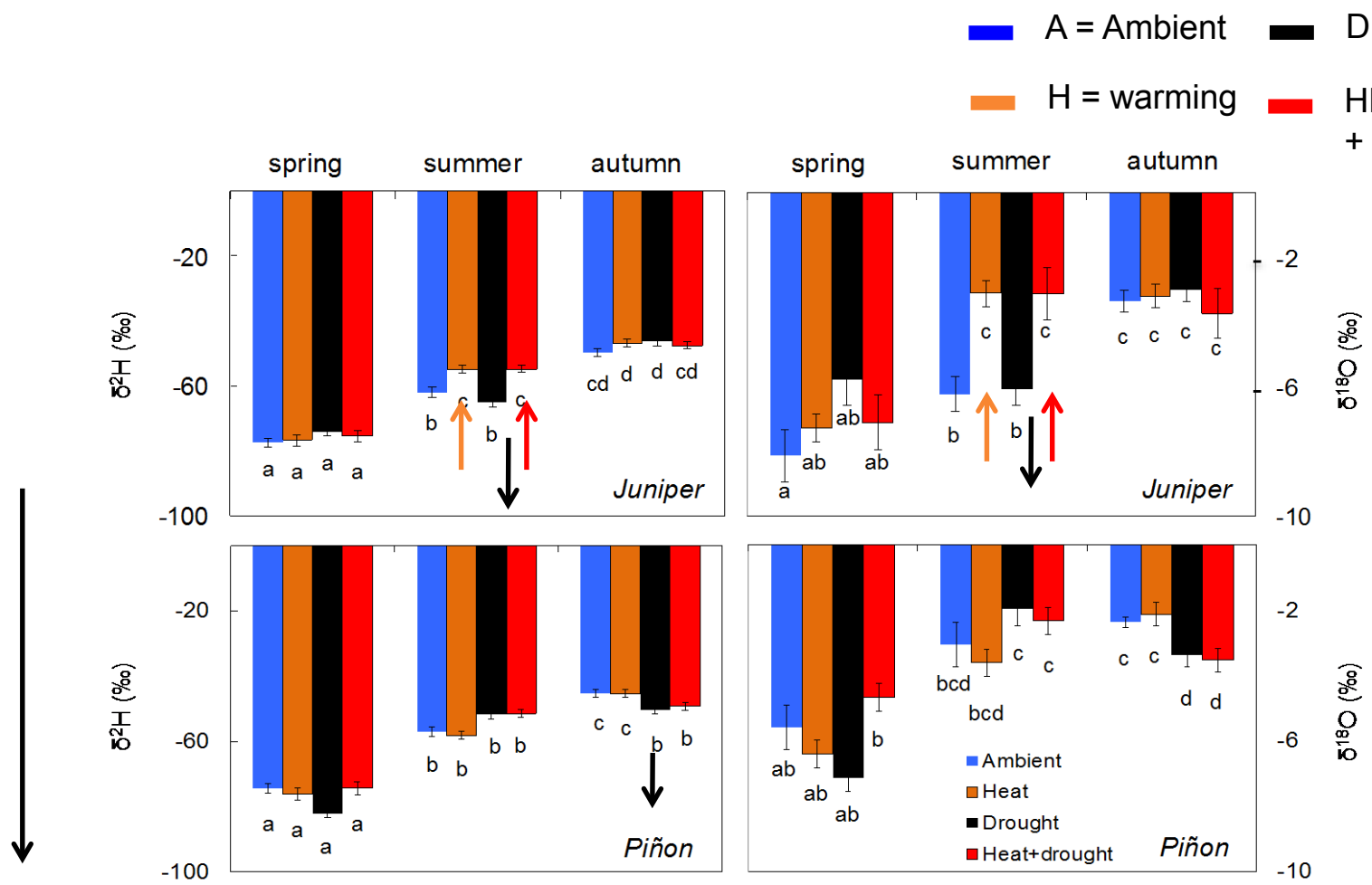
Acclimation of water uptake

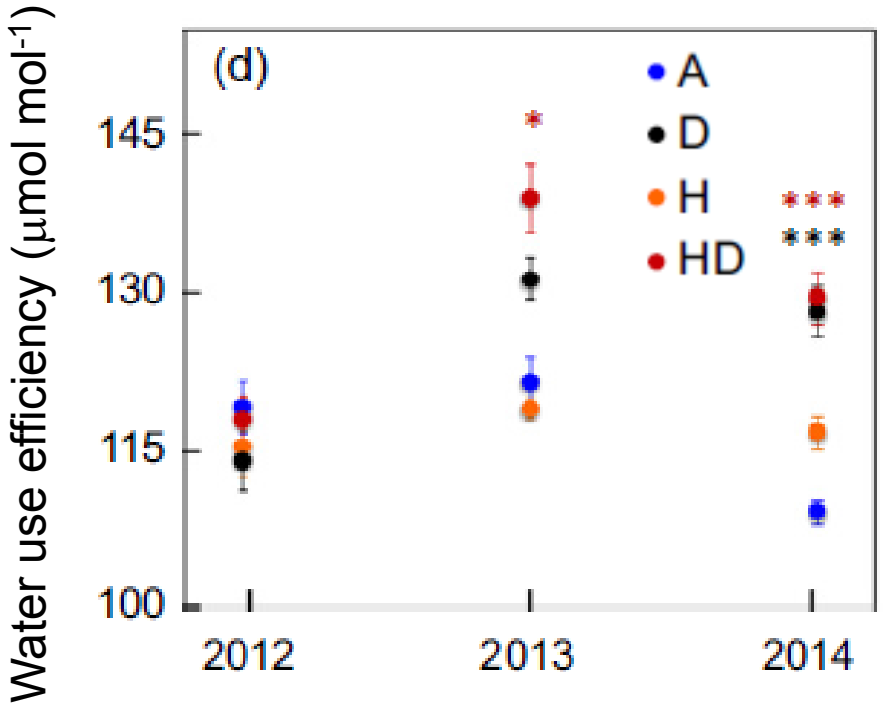


Higher contribution of deeper water sources / uptake

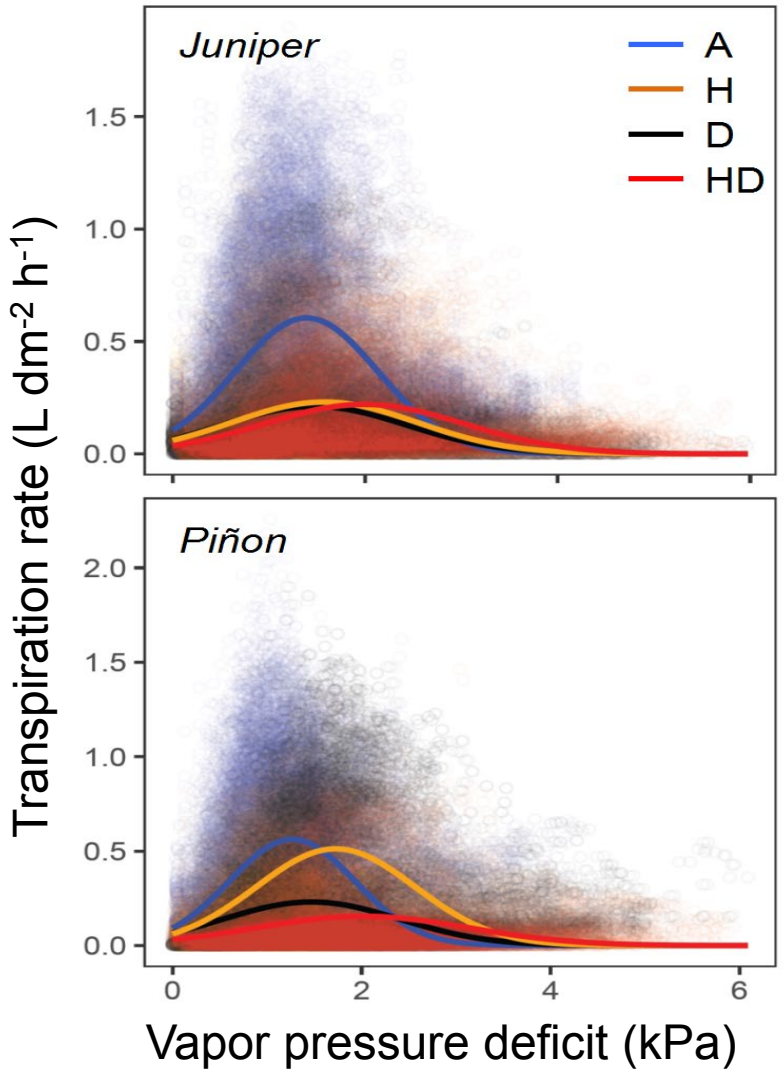
Grossiord et al. 2017 New Phytologist

Acclimation of water use

Grossiord et al. 2017 J. of Ecology

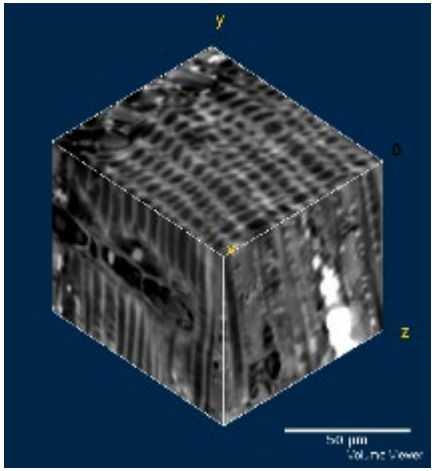


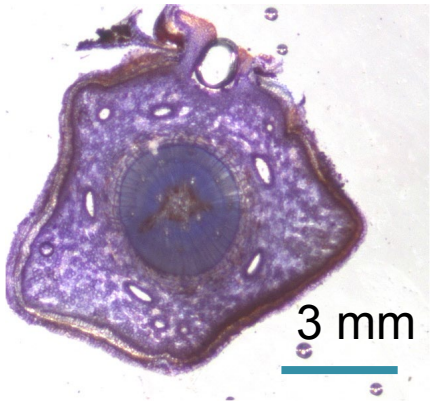
Grossiord et al. 2017 Plant, Cell and Environment



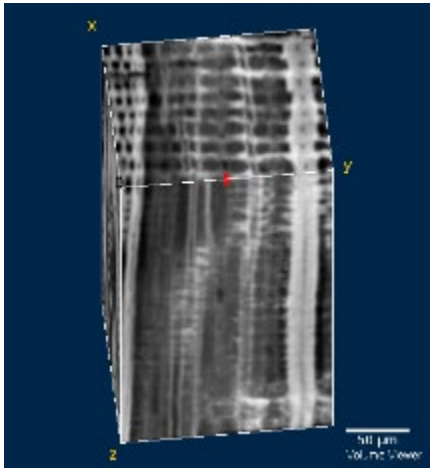
Structural acclimation is slower than physiological

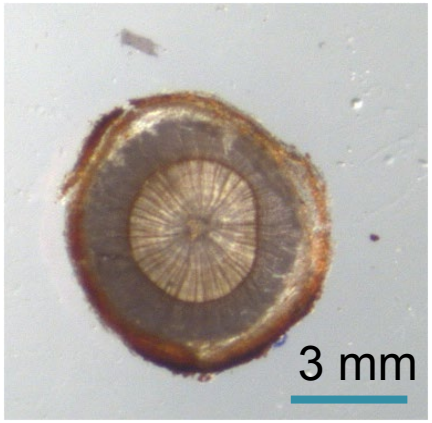
Pinus edulis

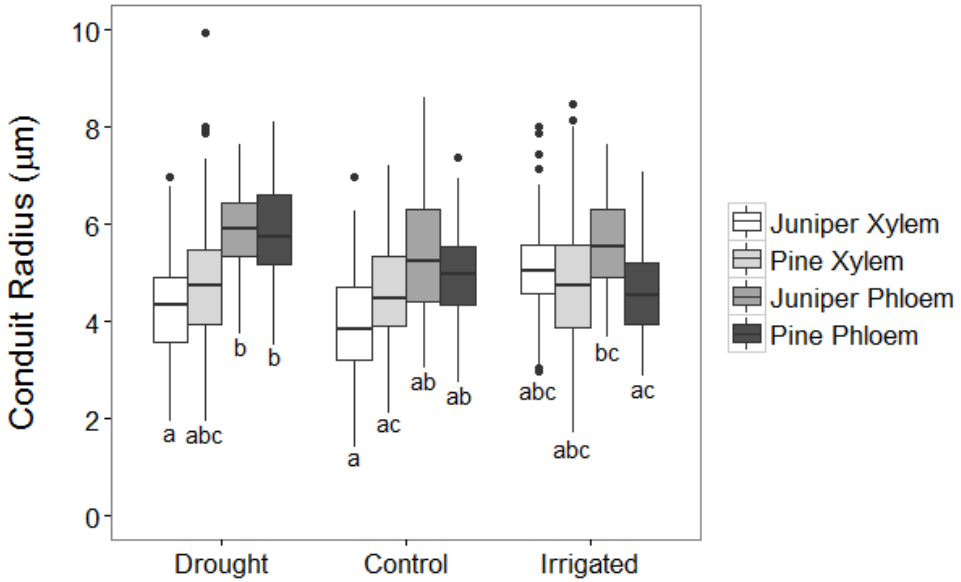




Juniperus monosperma



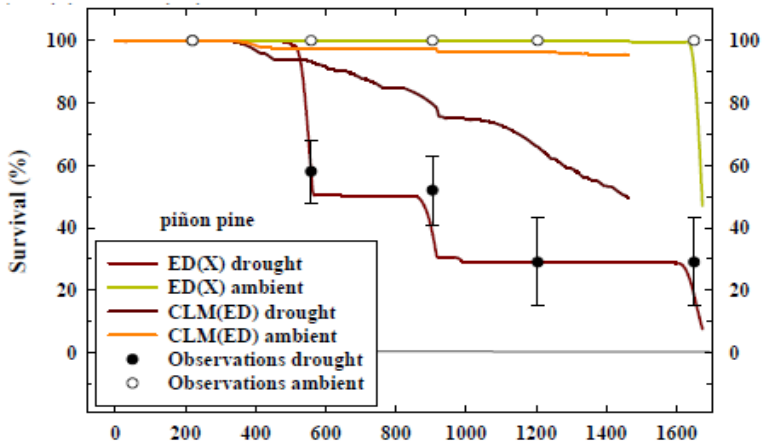




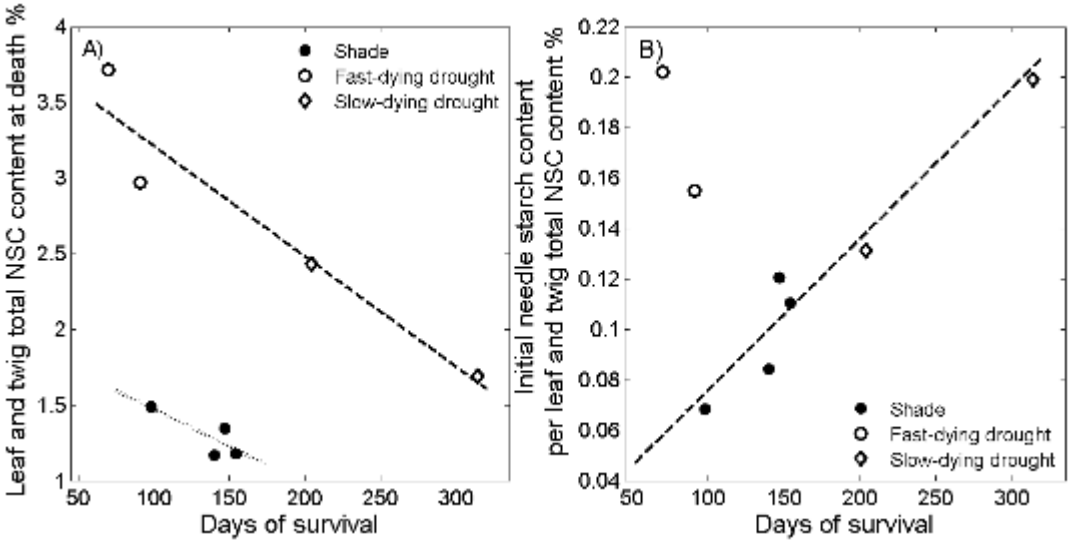
Sevanto et al. 2018 PCE

Carbohydrate transport capacity increases under drought in a desiccation avoiding species

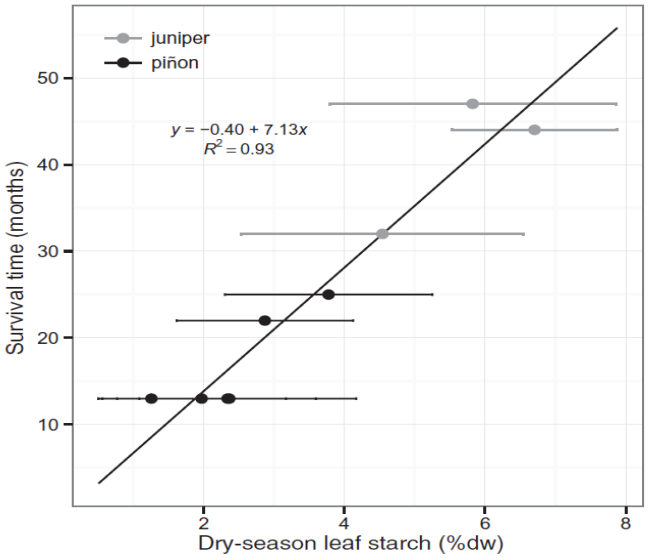
Variability in survival time of individuals is a major modeling challenge



McDowell et al. 2013

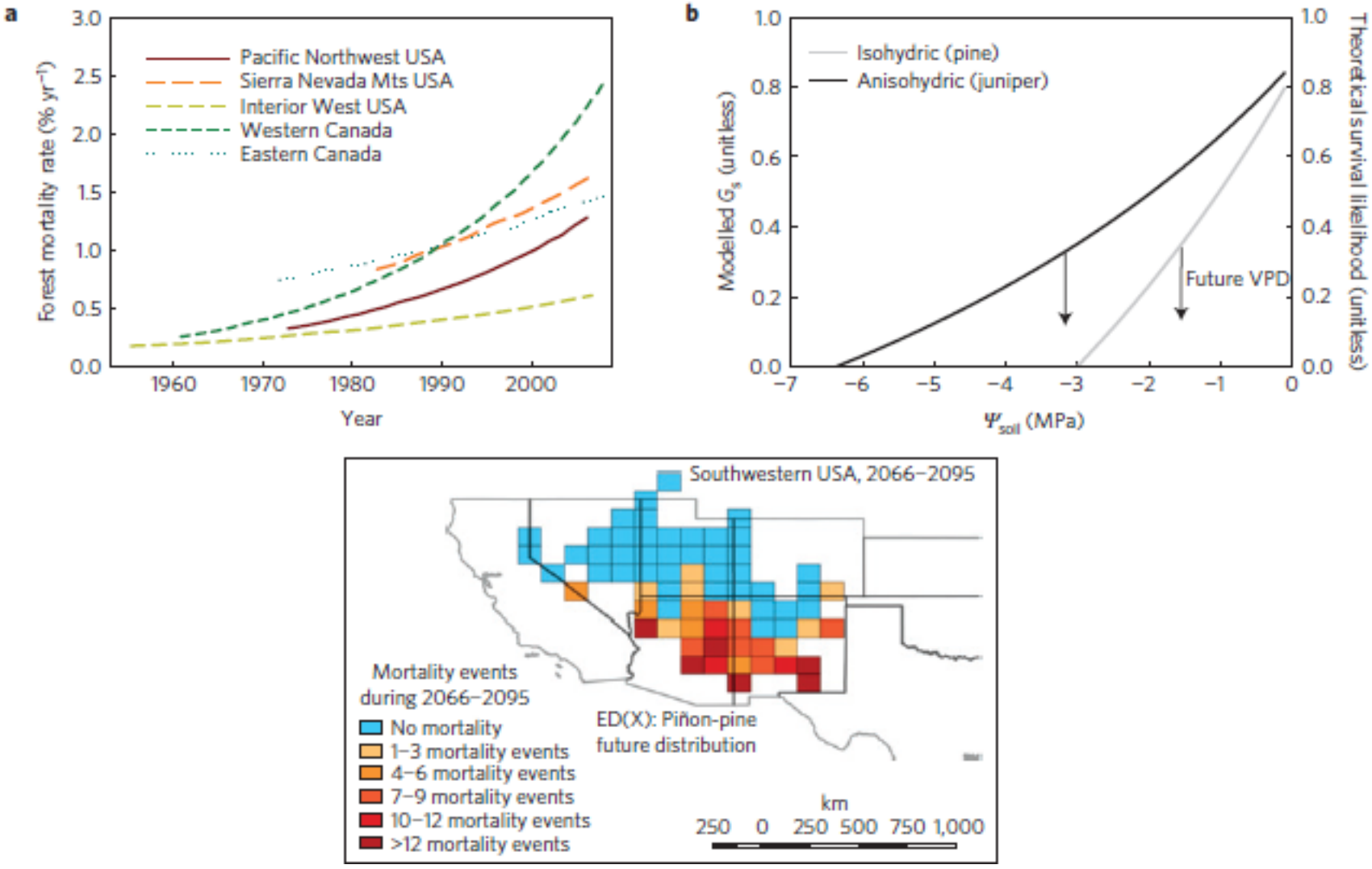


Sevanto et al. 2014 Plant, Cell and Environment



Dickman et al. 2014 Plant, Cell and Environment

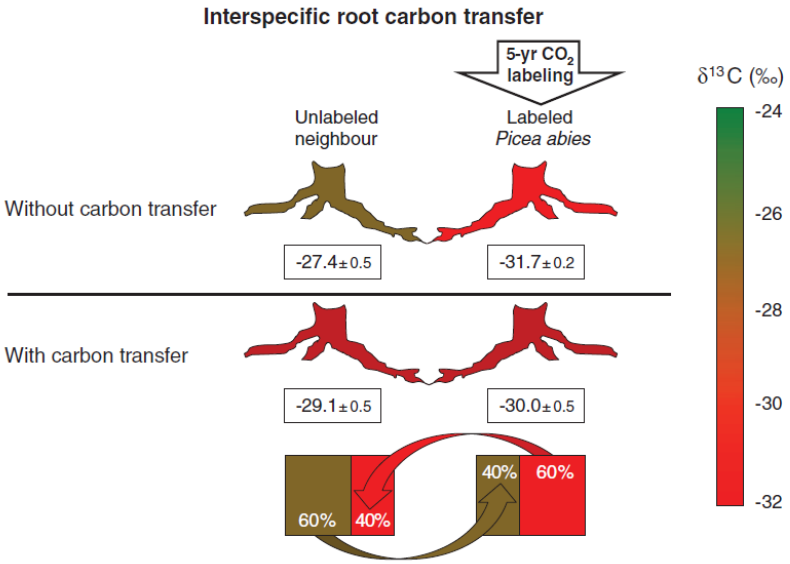
What is the destiny of PJ?



McDowell et al. 2015 NCC

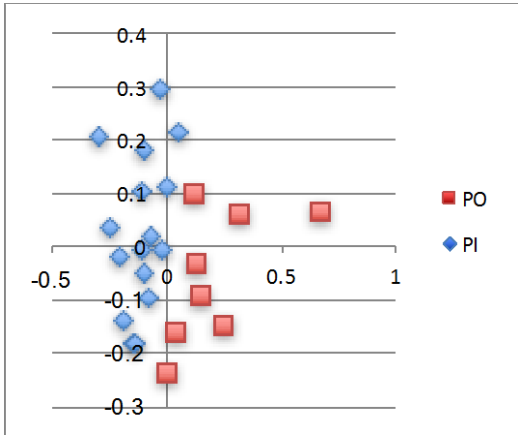
Maybe your support team matters most?

No fungi With fungi

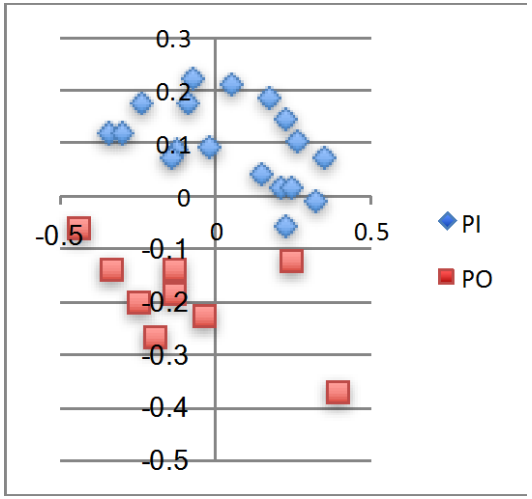


PIED is not the same as PIPO

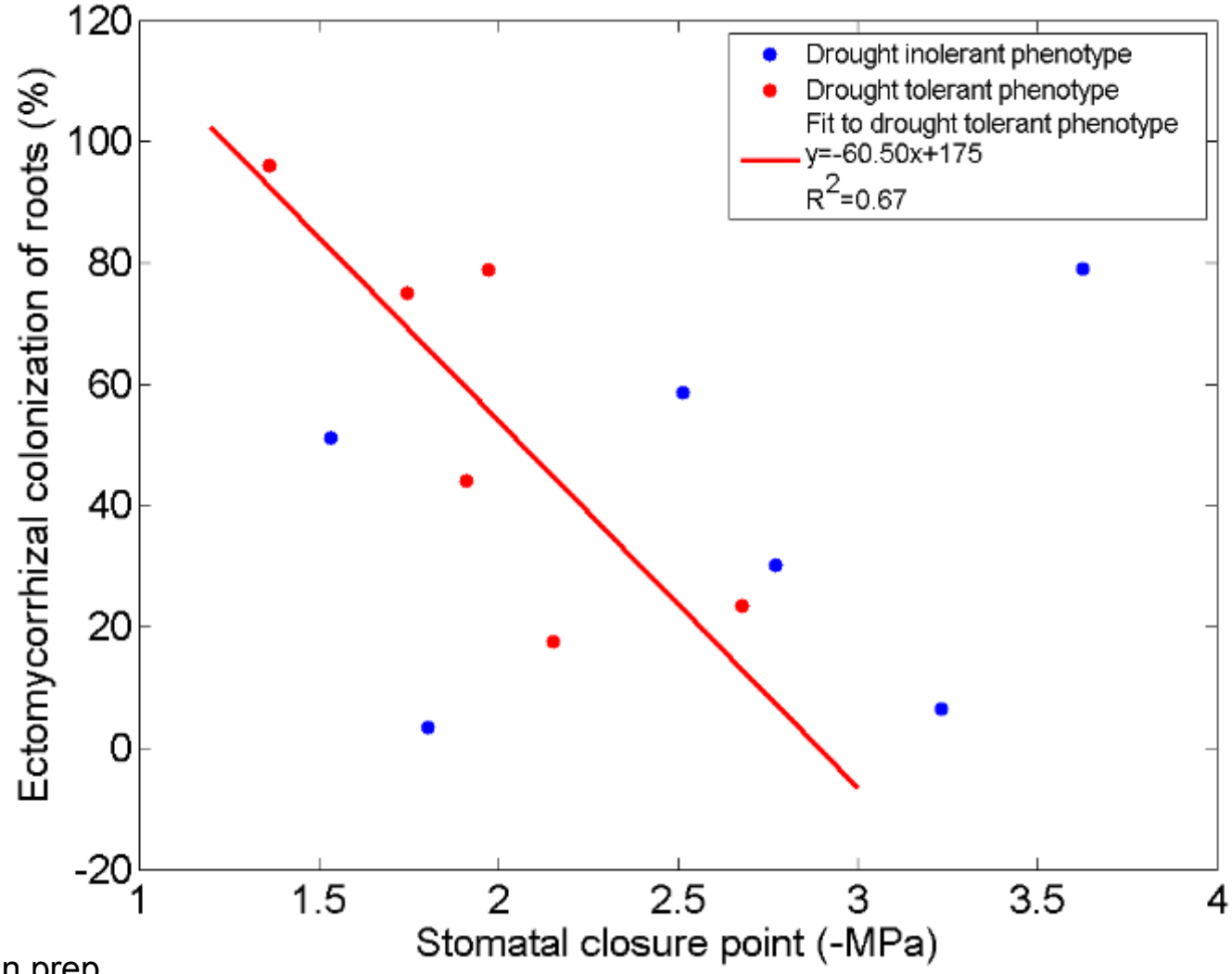
Fungi



Bacteria



Microbial associates affect drought tolerance in piñon pine



Sevanto et al. in prep