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| | |
|---|---|
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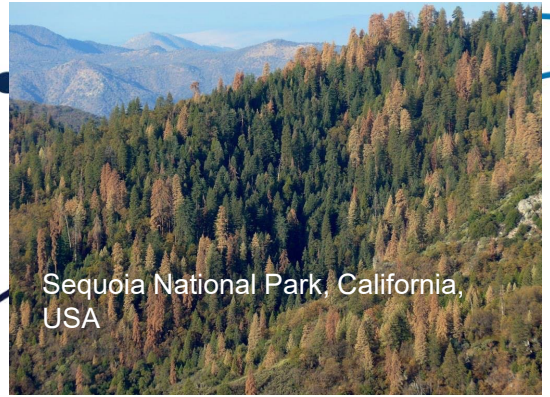
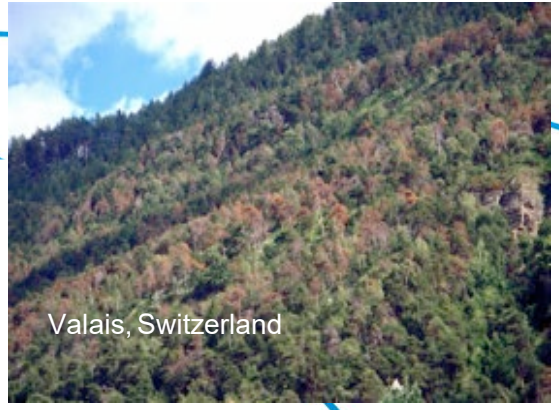
| Author(s): | Sevanto, Sanna Annika |
| Intended for: | Public talk at University of Texas, Dallas GeoClub |
| Issued: | 2021-02-11 |








# “Vegetation-climate interactions in the changing world: What determines who survives, and what can we do about it”

Sanna Sevanto

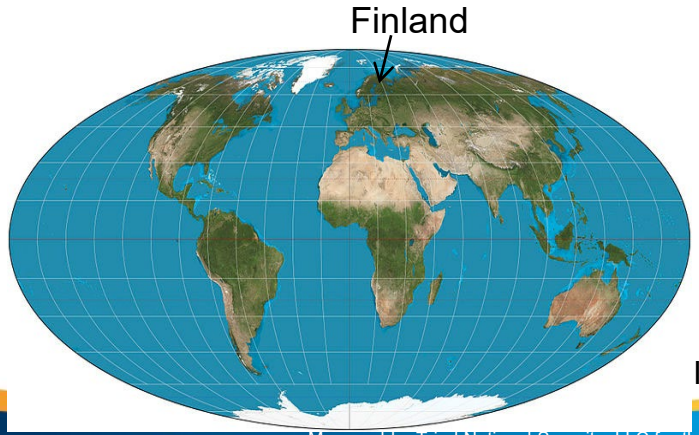
Earth and Environmental Sciences Division

Los Alamos National Laboratory

Feb 12th, 2021

# Who am I and how did I get here?

- Sanna Sevanto
- Staff Scientist at Los Alamos National Laboratory
- PhD in physics, Master's in Materials Science, University of Helsinki, Finland

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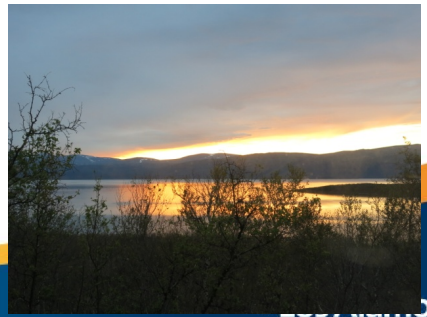
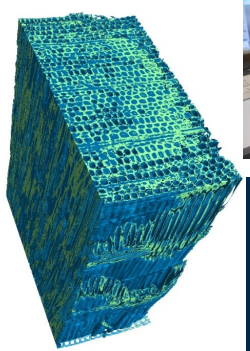
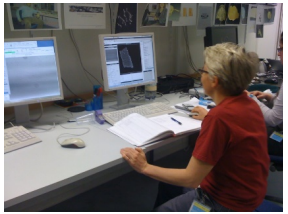


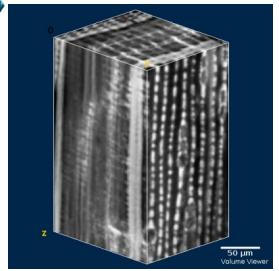
# What do I do?

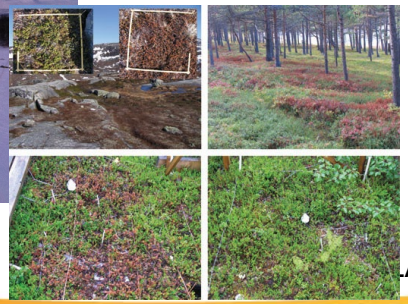
**Precipitation**

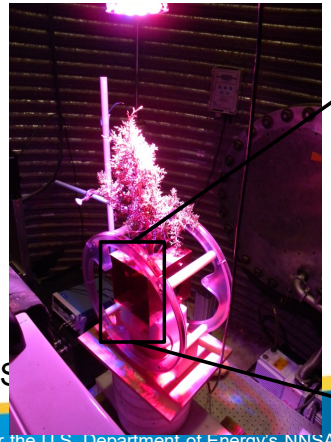
| Temperature | Ambient P | Drought |
|---|---|---|
| Ambient T |  |  |
| ~+5°C |  |  |
| Ambient T Chamber |  | |

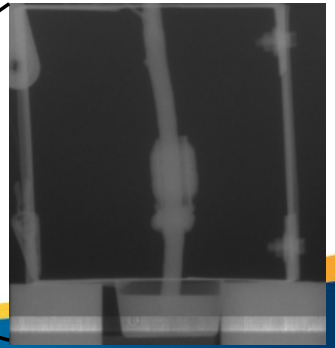




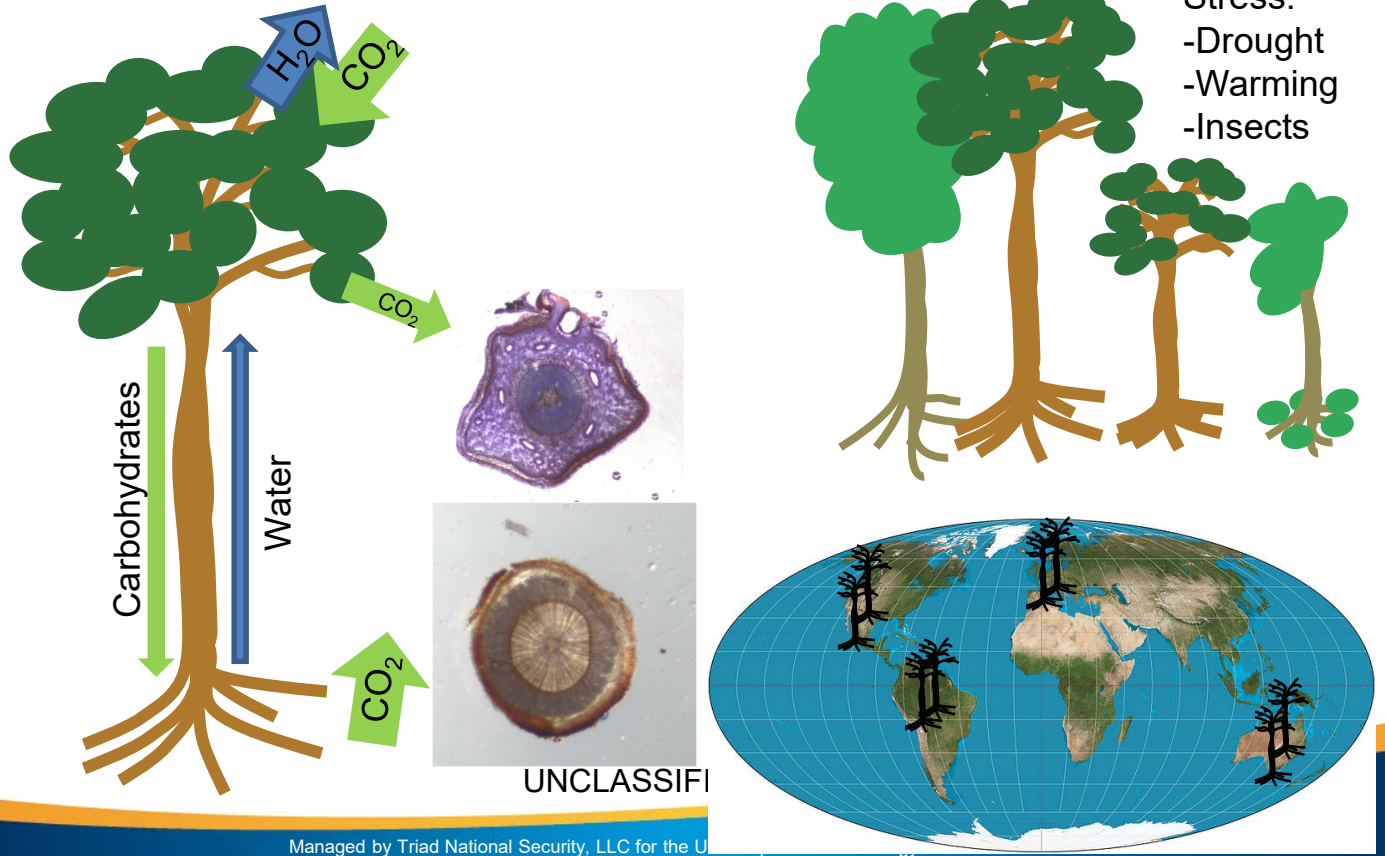






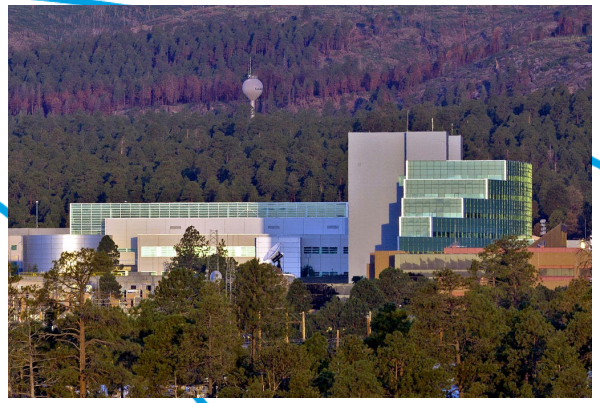
# Goal: To understand how cellular-level function leads to global-scale phenomena



# Acknowledgements:


**Los Alamos National Laboratory:**

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



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

# Acknowledgements:


## Los Alamos National Laboratory:

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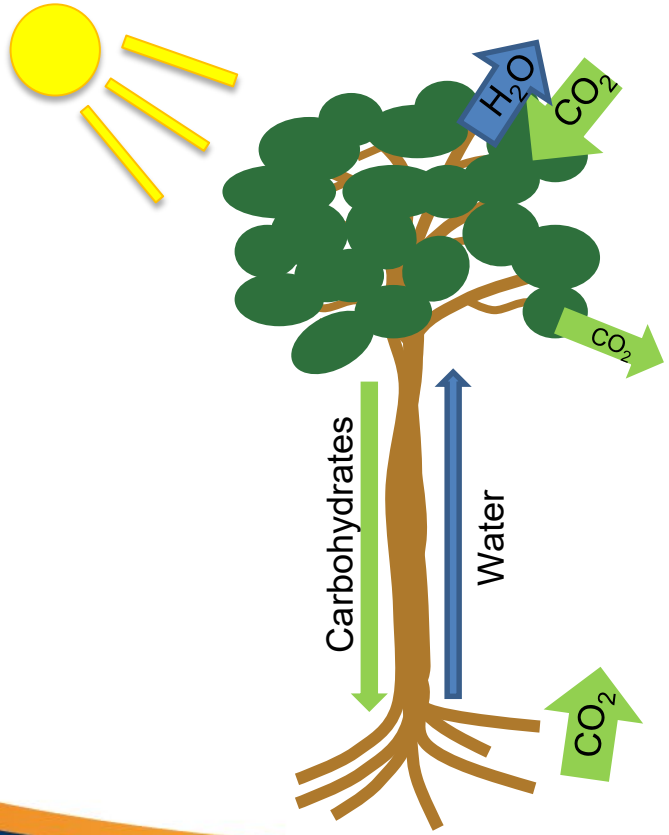
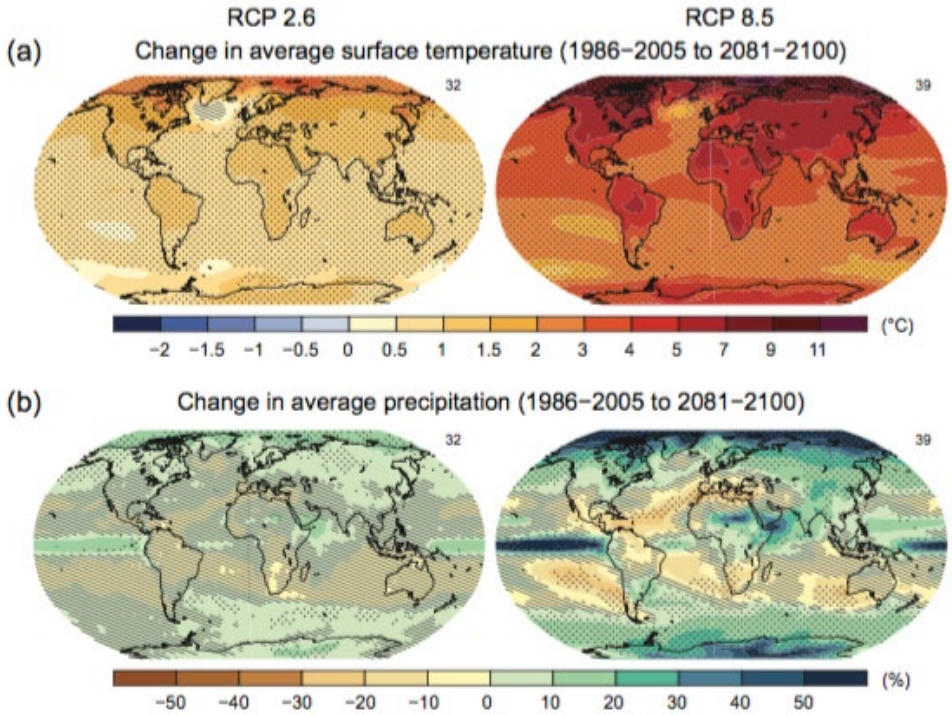
Rick Meinzer, David Woodruff, Kate McCulloh, Danielle Marias Oregon State University
Alberto Vilagrosa, University of Alicante, Spain
Michel Vennetier, IRSTEA, France

# What do plants do from climate perspective:



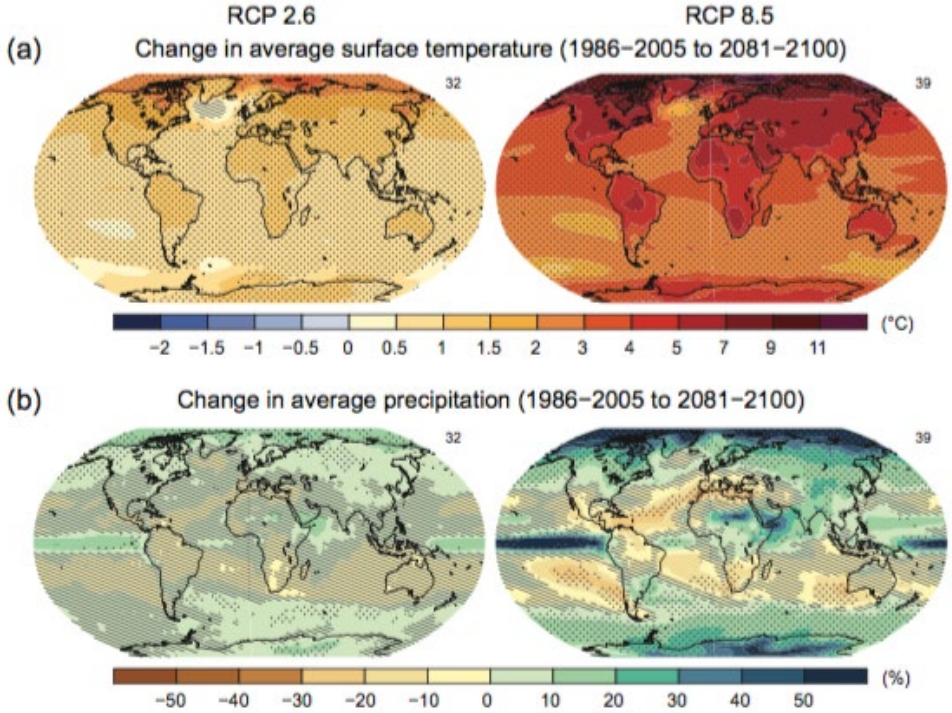
# Climate change impacts on forests




**+5°C** by 2100 under business-as-usual scenario

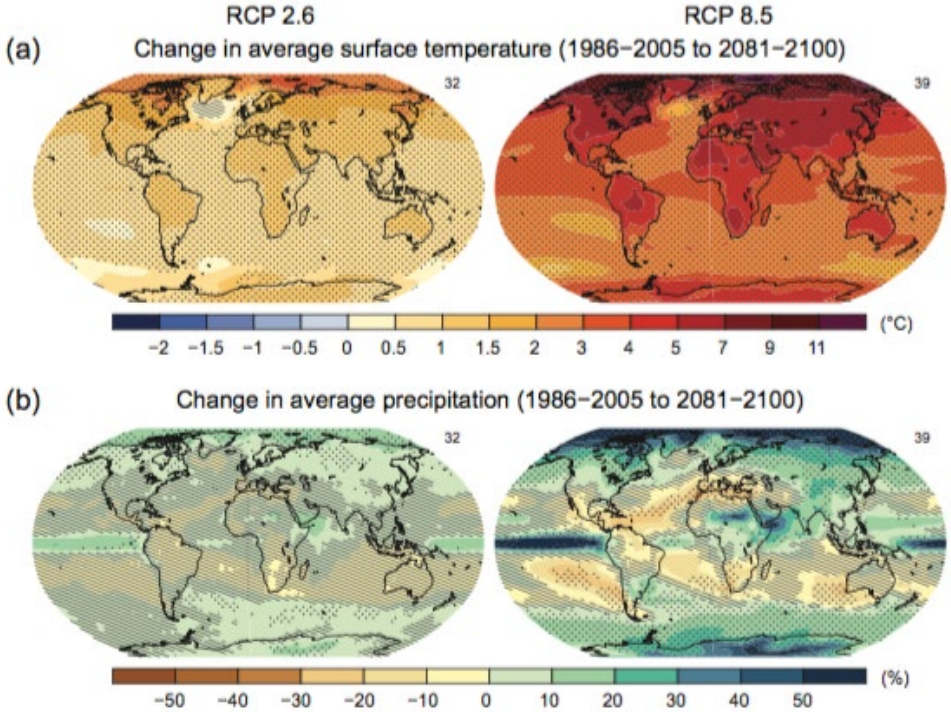
**More extreme precipitation** events

# Climate change impacts on forests



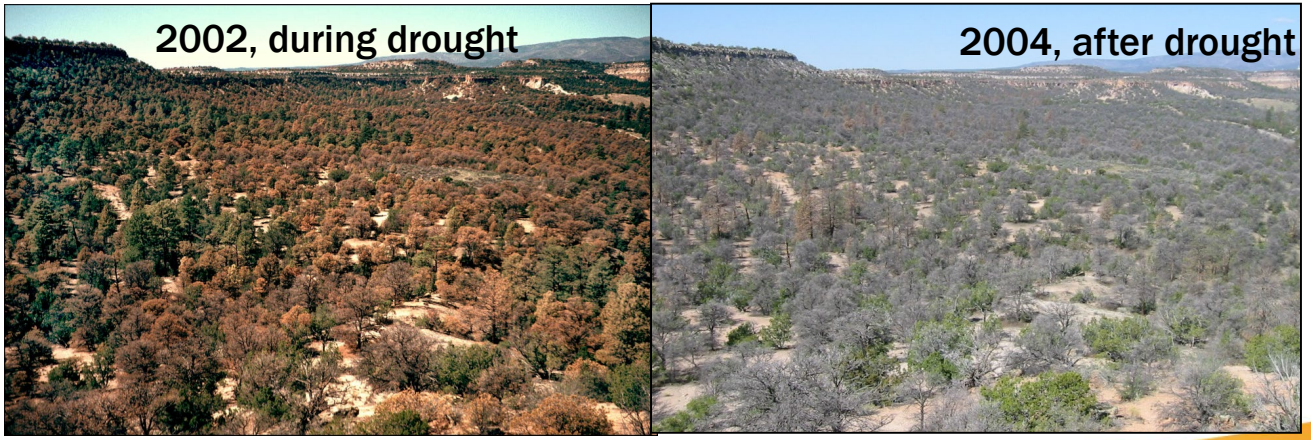

**Higher evaporative demand**

# Climate change impacts on forests

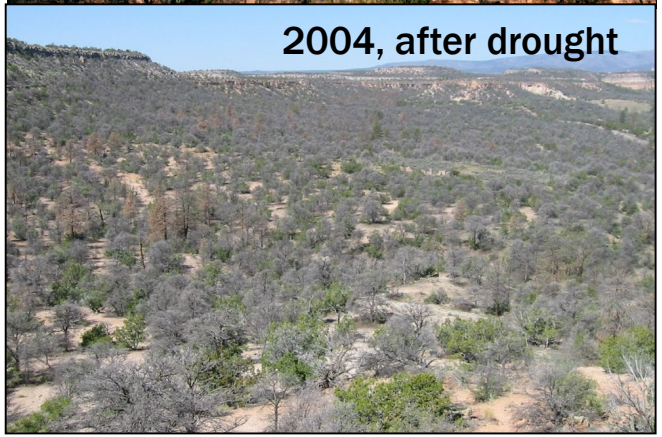


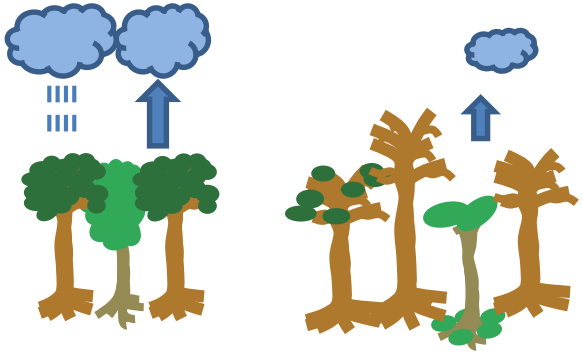

**Future droughts will be superimposed on warmer conditions**

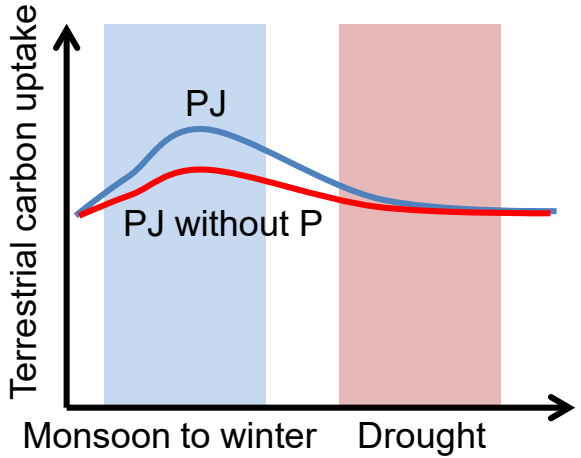
# What happened here:



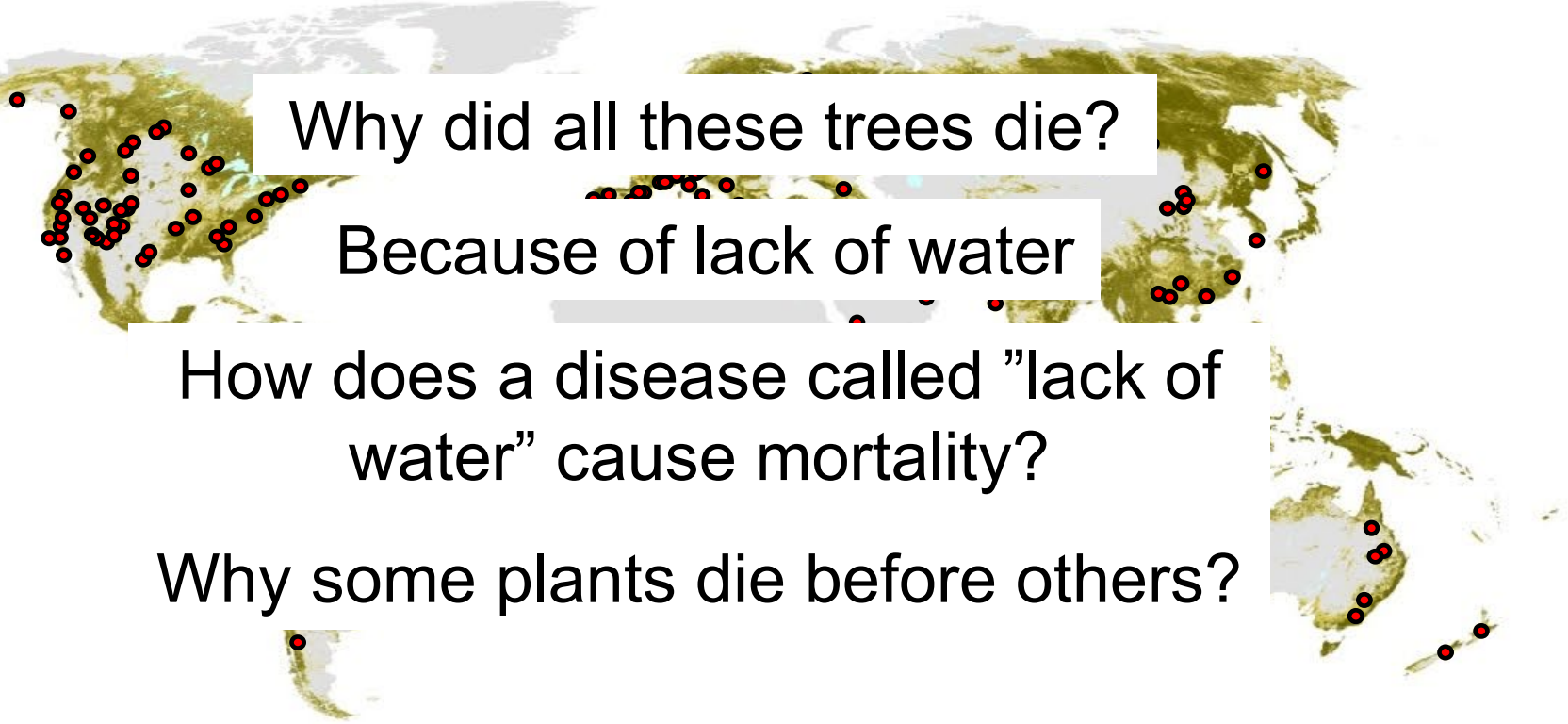
# What does this means for the water cycle:



# Motivation:



Why did all these trees die?

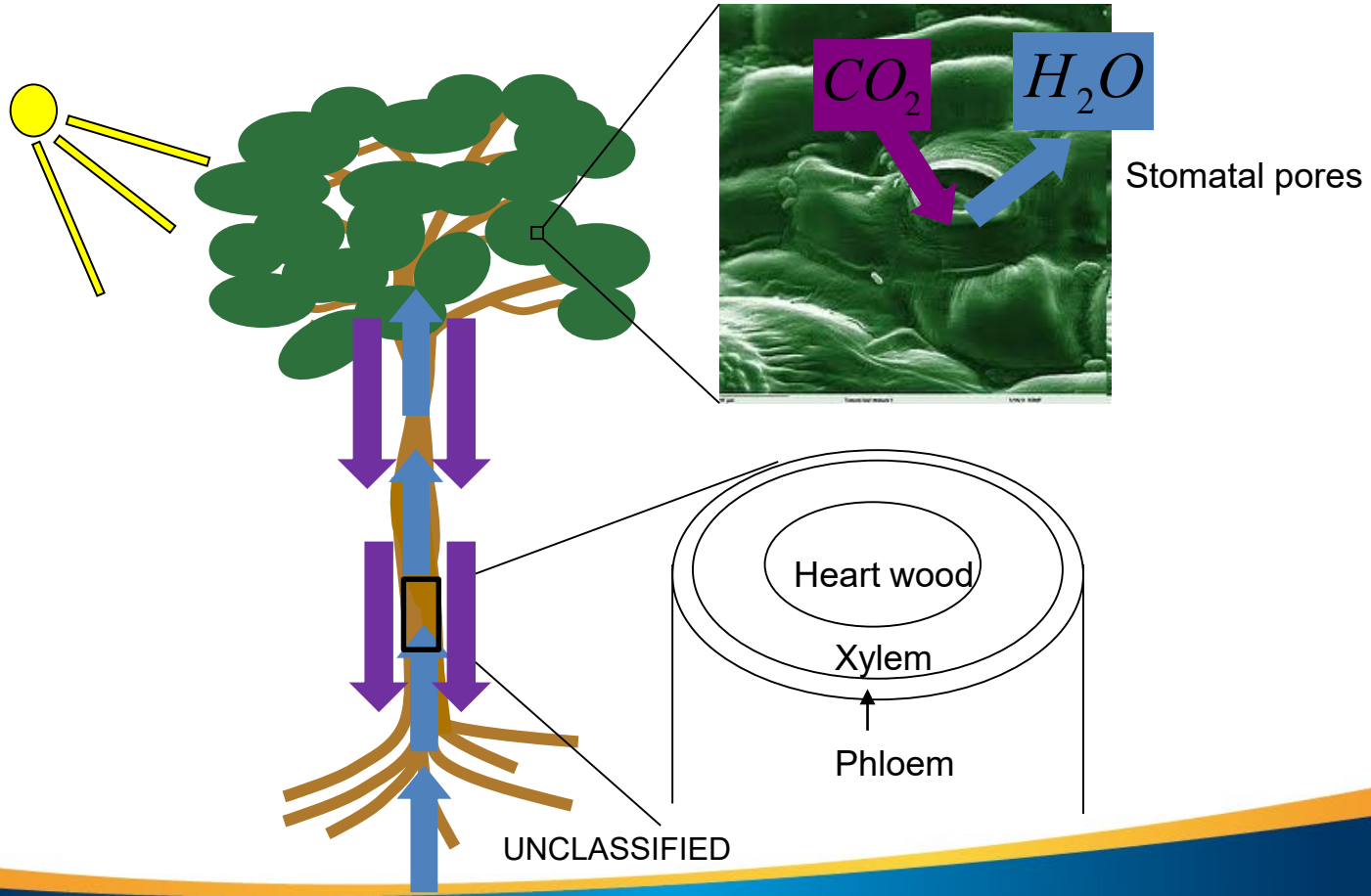
Because of lack of water

How does a disease called ”lack of water” cause mortality?

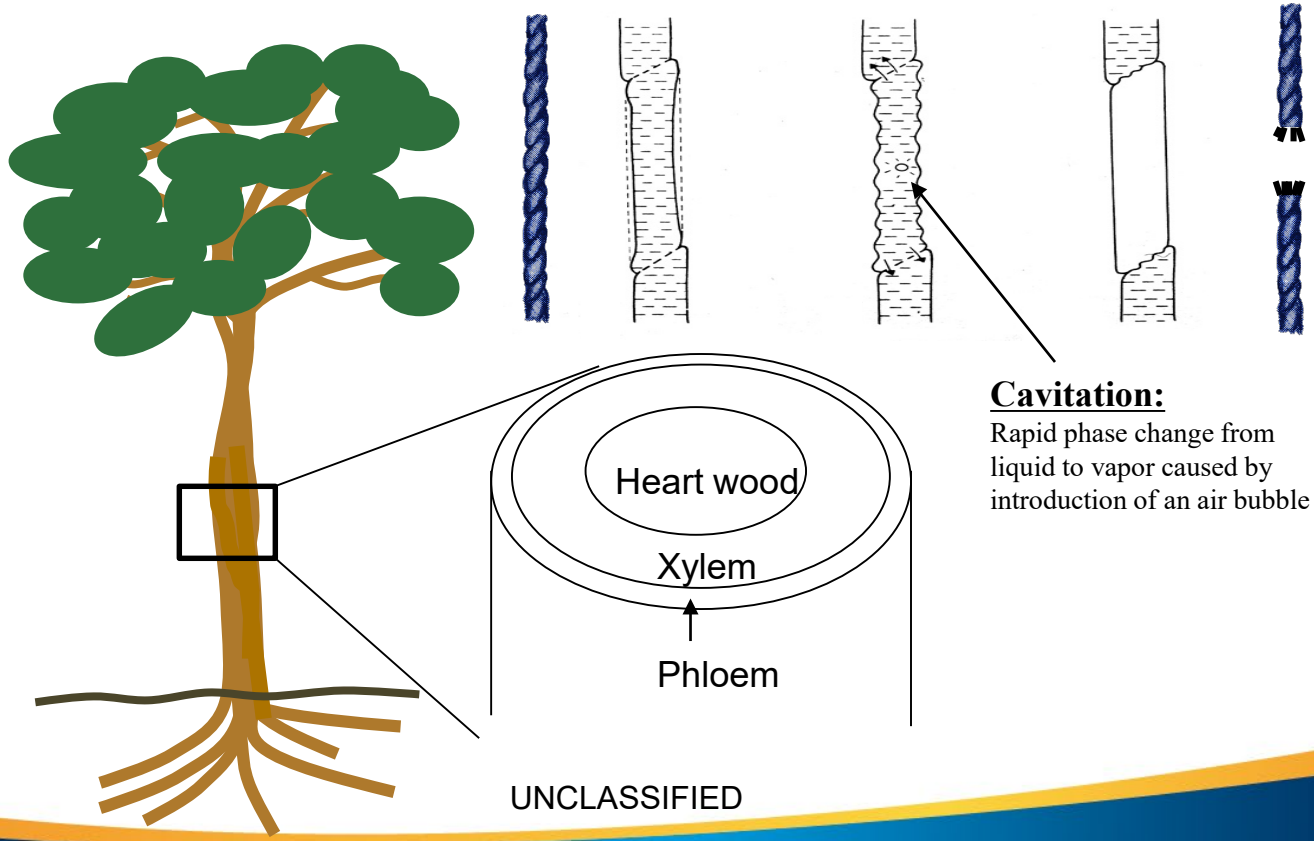
Why some plants die before others?

Allen, Breshears & McDowell 2015

# How does a plant function?



# Basics of water flow in trees




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

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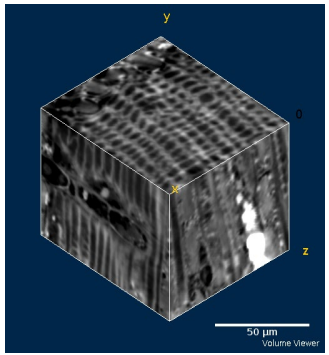
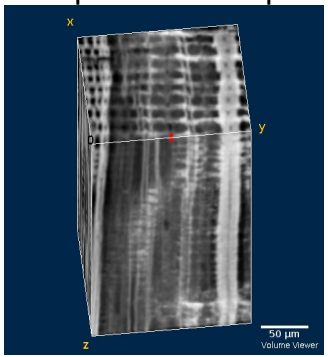
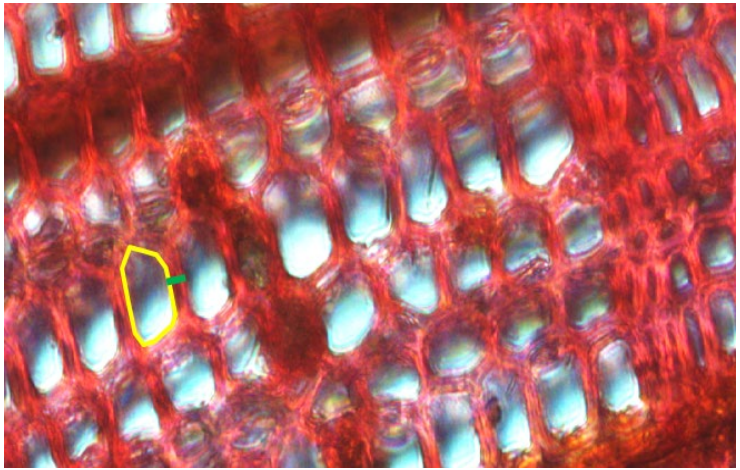
# Hydraulic capacity depends on anatomy

Pinus edulis




Juniperus monosperma



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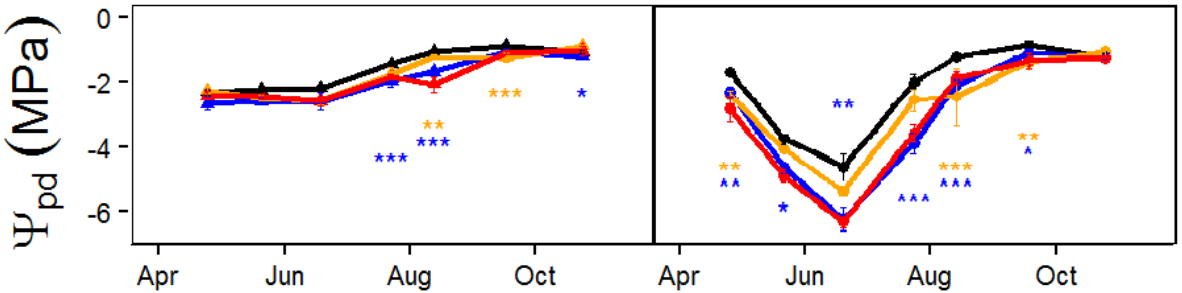
# Plants differ in their water and carbon use

**Piñon pine (*P. edulis*)**

**Juniper (*J. monosperma*)**

Leaf water potential in summer 2013

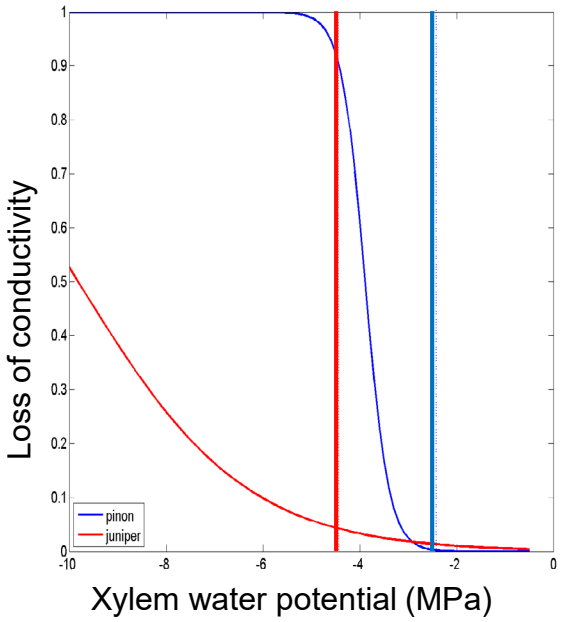



Garcia-Forner et al. 2016 PCE

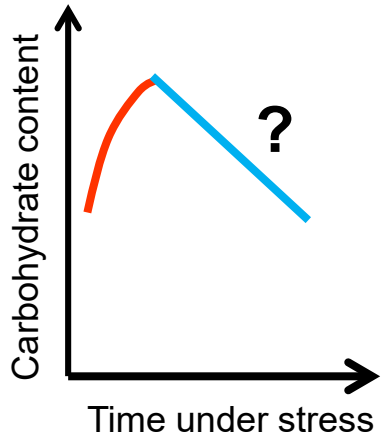
# Plant pairs similar to pinon and juniper co-exist everywhere

# Hypotheses of mortality mechanisms

**Hydraulic failure:**

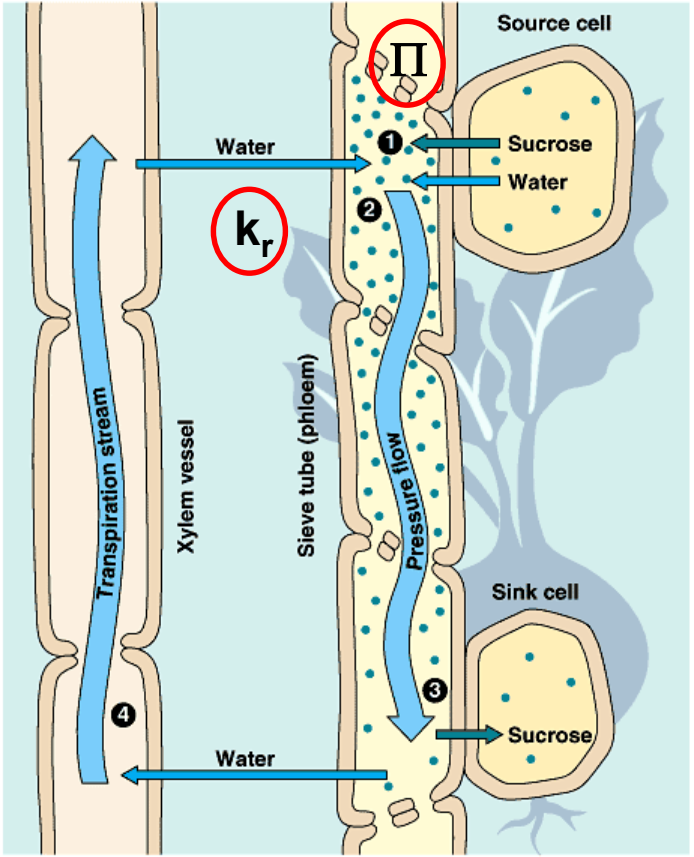



**Carbon starvation:**

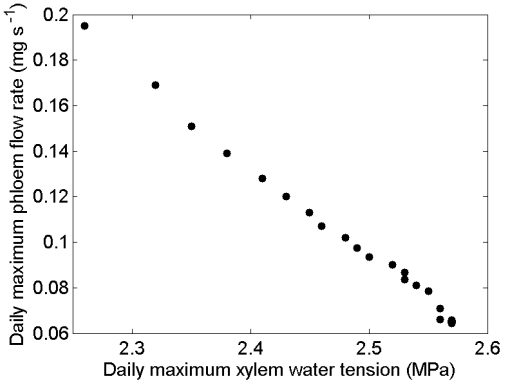


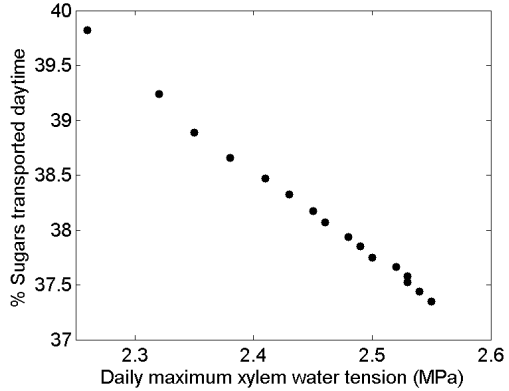

McDowell et al. 2008, New Phytologist

# Why sugar transport matters



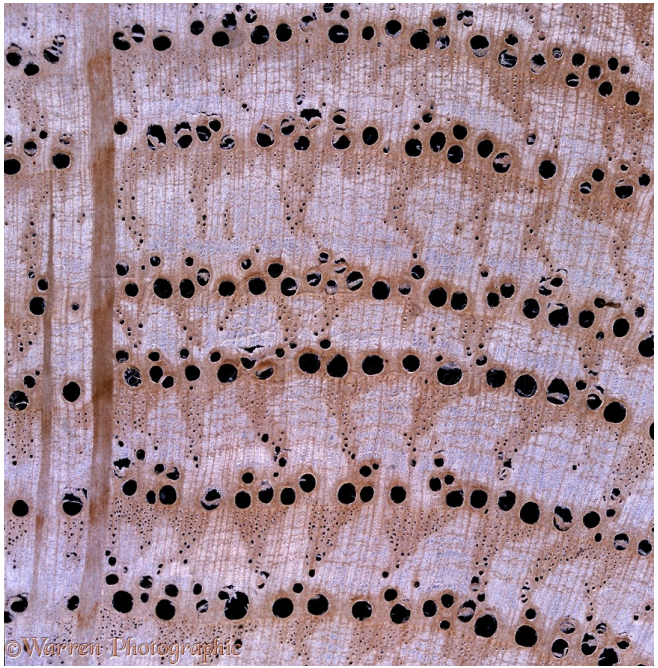


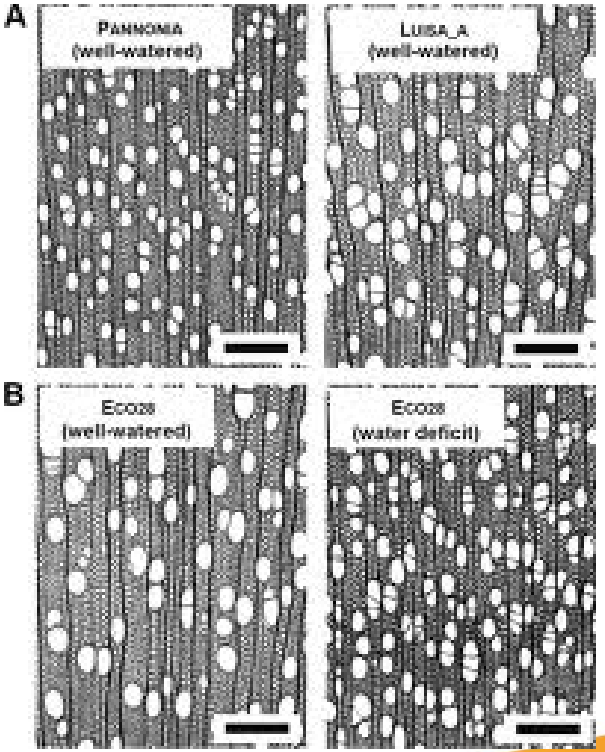



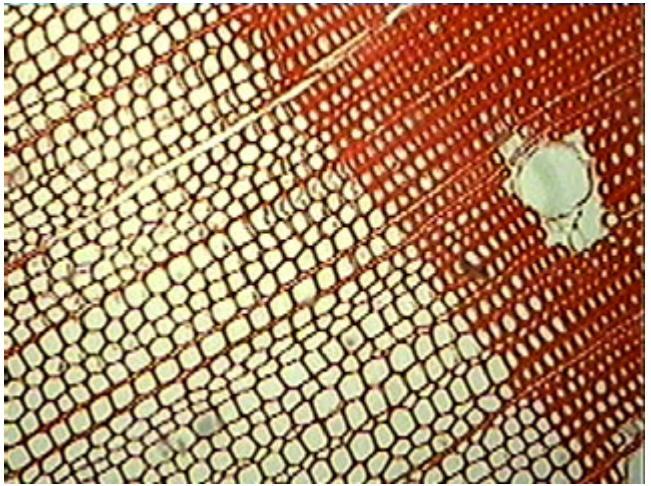




Model simulations Teemu Hölttä, University of Helsinki

# Tree structure determines hydraulic vulnerability:







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# How species avoid mortality

**Trees** can respond to climate change by:

**Migration** **60-250 m $yr^{-1}$**

# How species avoid mortality

**Trees** can respond to climate change by:

**Adaptation** **50-5000 years**

**Migration** **60-250 m $yr^{-1}$**

# How species avoid mortality

**Trees** can respond to climate change by:

**Adaptation** 50-5000 years

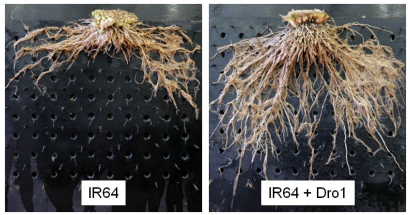
**Migration** 60-250 m $yr^{-1}$

**Acclimation**

# Acclimation processes to drought and warming

## Acclimation to drought

Thicker and shorter needles




Growing deeper roots

## Acclimation to warming

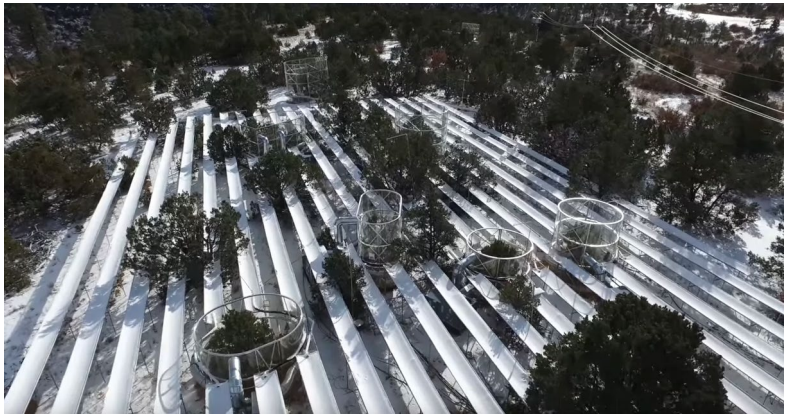
Advanced phenology

Higher productivity

# Tree SUrvival and MOrtality site:

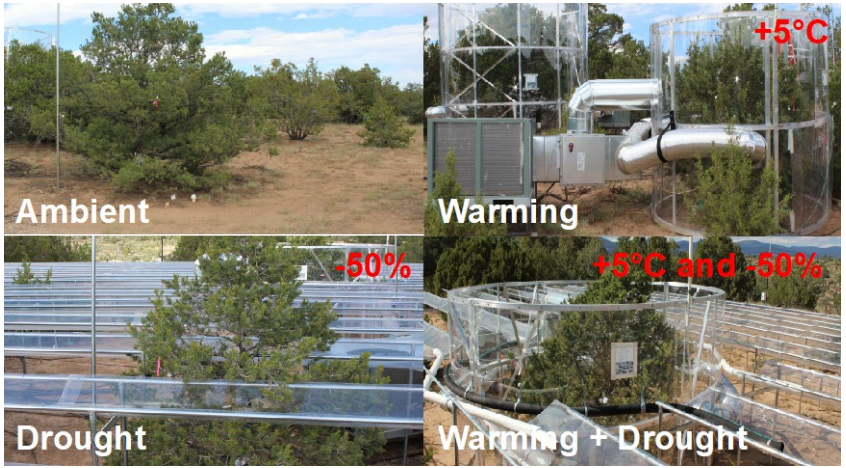

Treatments mimicking expected conditions in NM in 2100 started in June 2012

# Case study: the SUMO experiment

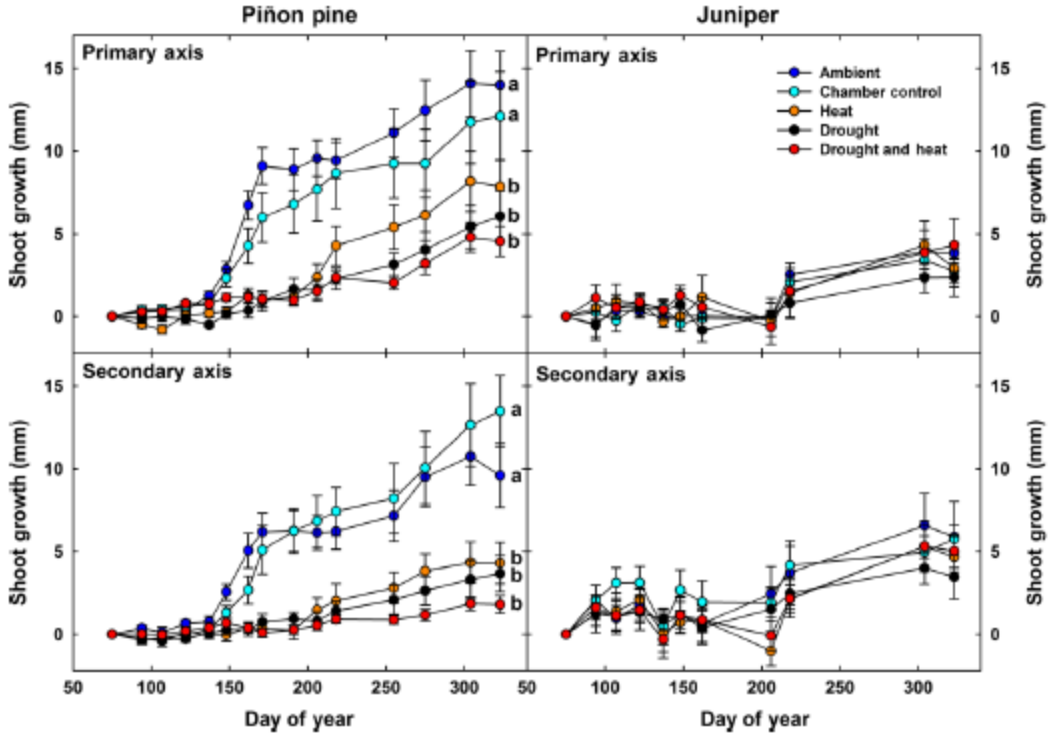


SUMO Forest SUrvival & MOrtality Understanding & Prediction

Between 60 and 75 year-old trees →



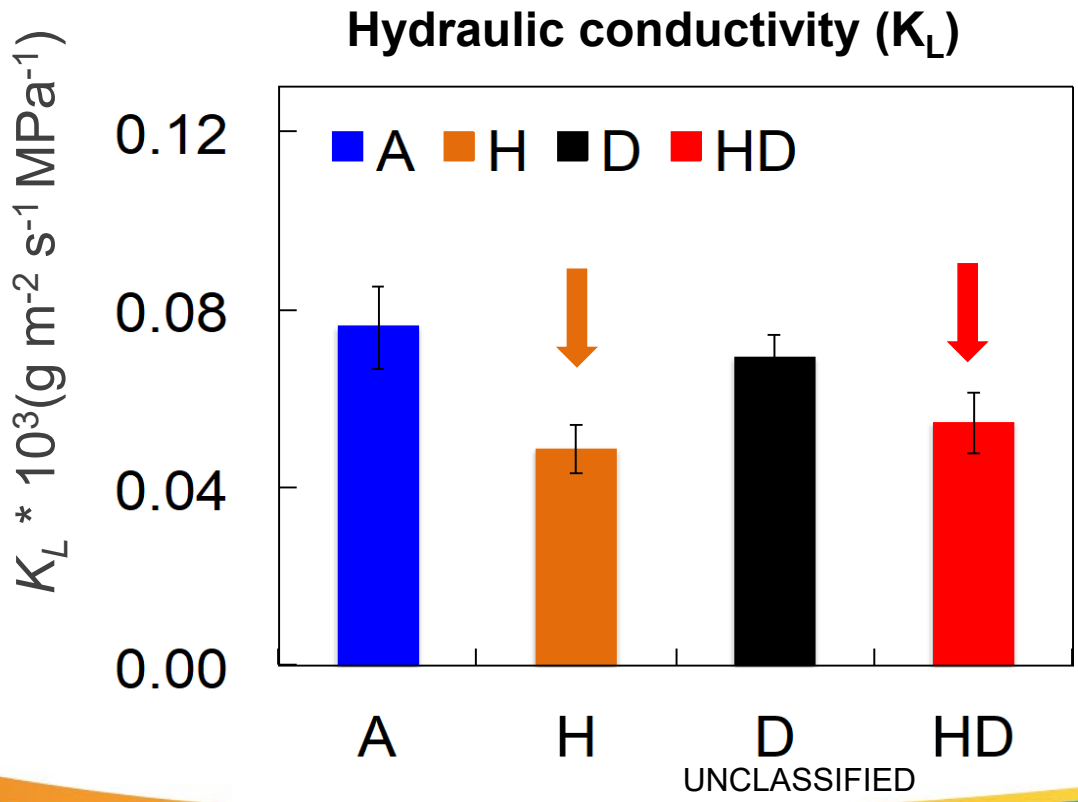
# What do drought and warming do to plant growth?




Adams et al. 2015 Global Change Biology

Grossiord et al. 2017 J. of Ecology

# What do drought and warming do to plant water uptake

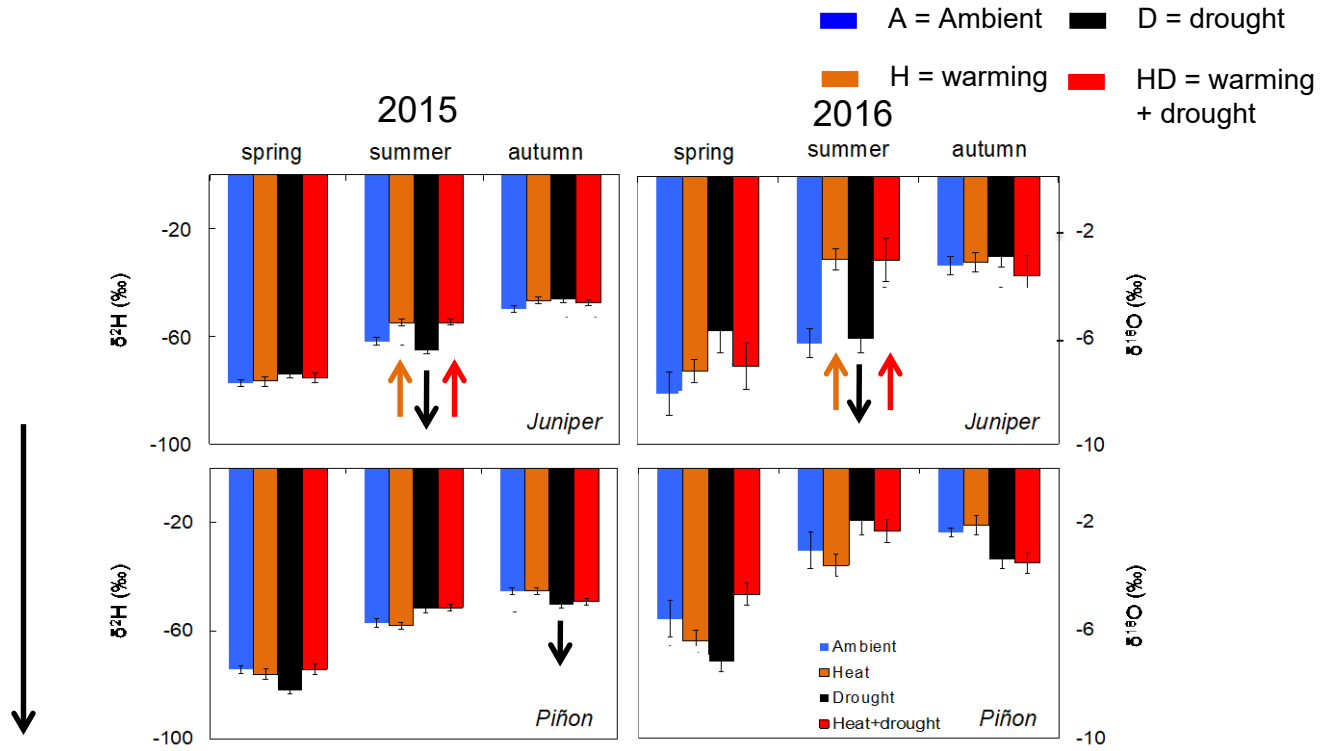



**HIGHER DAMAGES (CAVITATION) TO HYDRAULIC SYSTEM UNDER WARMING in Pine**

A = Ambient
D = drought
H = warming
HD = warming + drought

Grossiord et al. 2017 PCE

# What do drought and warming do to plant water uptake




**Higher contribution of deeper water sources / uptake**

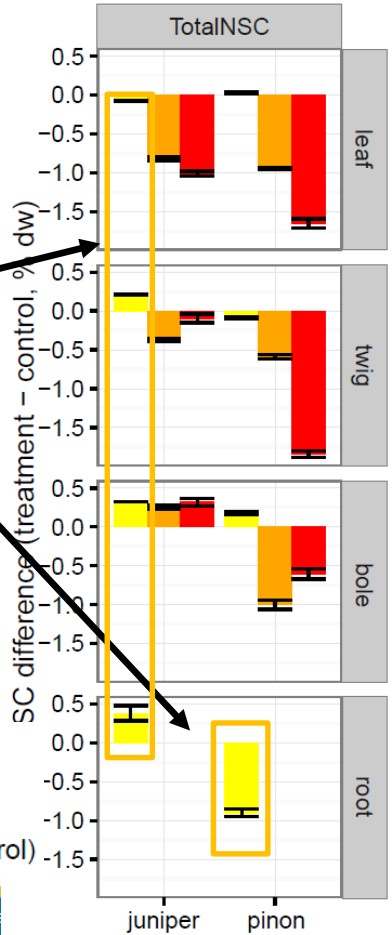
Grossiord et al. 2017 New Phytologist

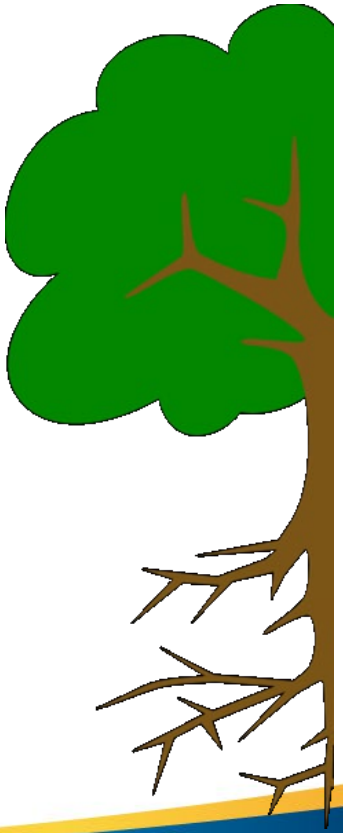
# Carbon storage

**Drought**:

**juniper**: increase whole-tree NSC

**piñon**: decrease root NSC



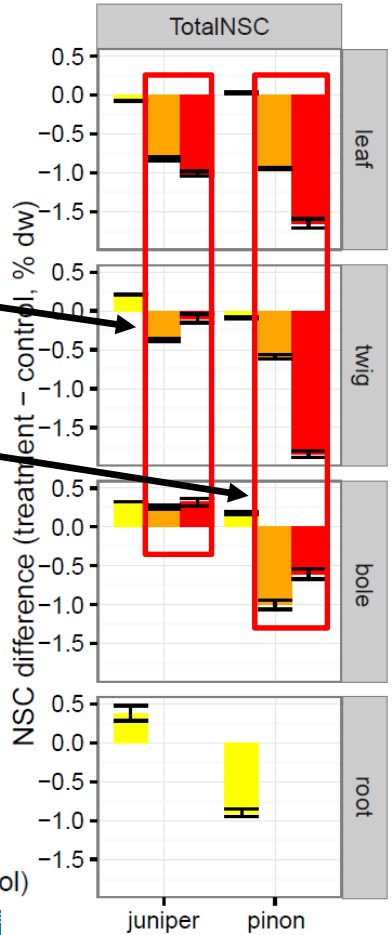
Drought - Ambient
Heat - (Chamber Control)
(Heat + Drought) - (Chamber Control)

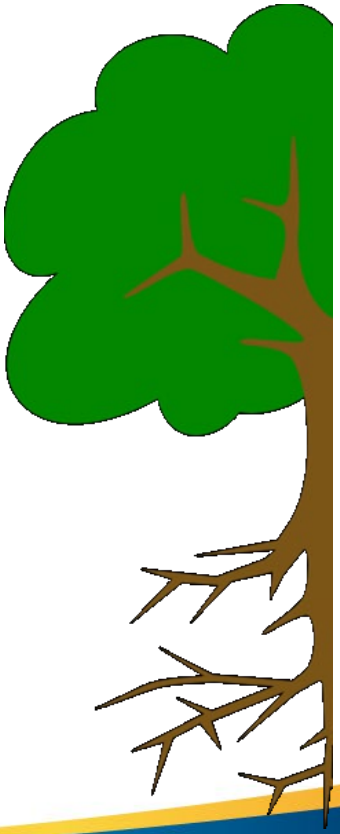
# Carbon storage

Heat & Heat + Drought:

**juniper**: shift allocation from canopy to stem

**piñon**: reduce whole-tree NSC



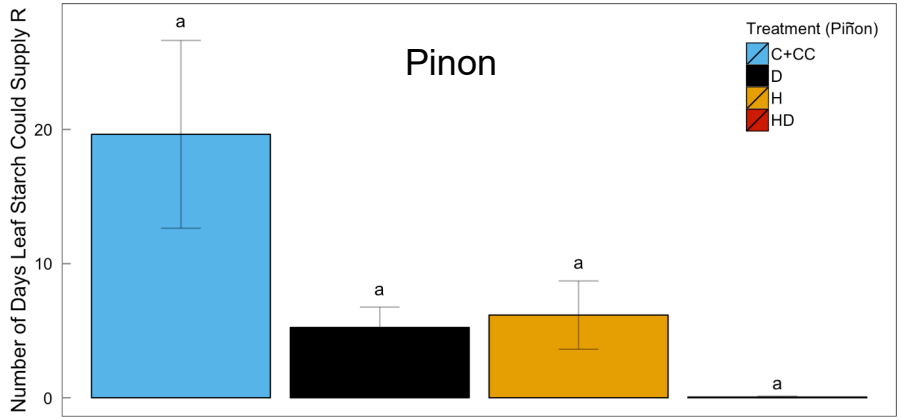



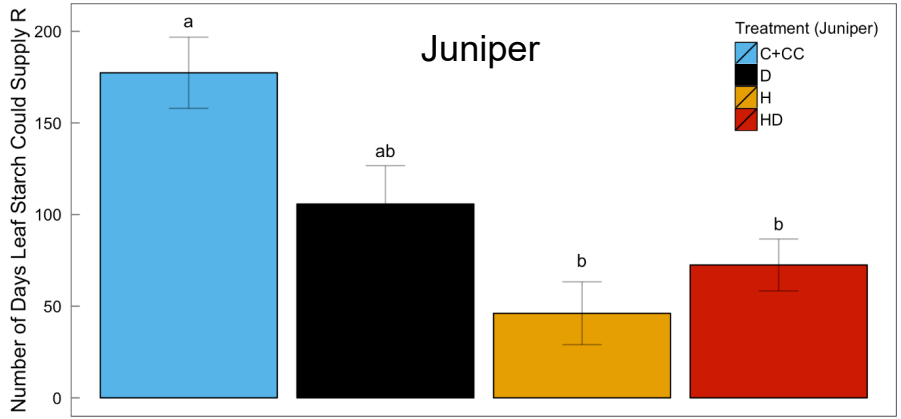
Drought - Ambient

Heat - (Chamber Control)

(Heat + Drought) - (Chamber Control)

# Carbon balance

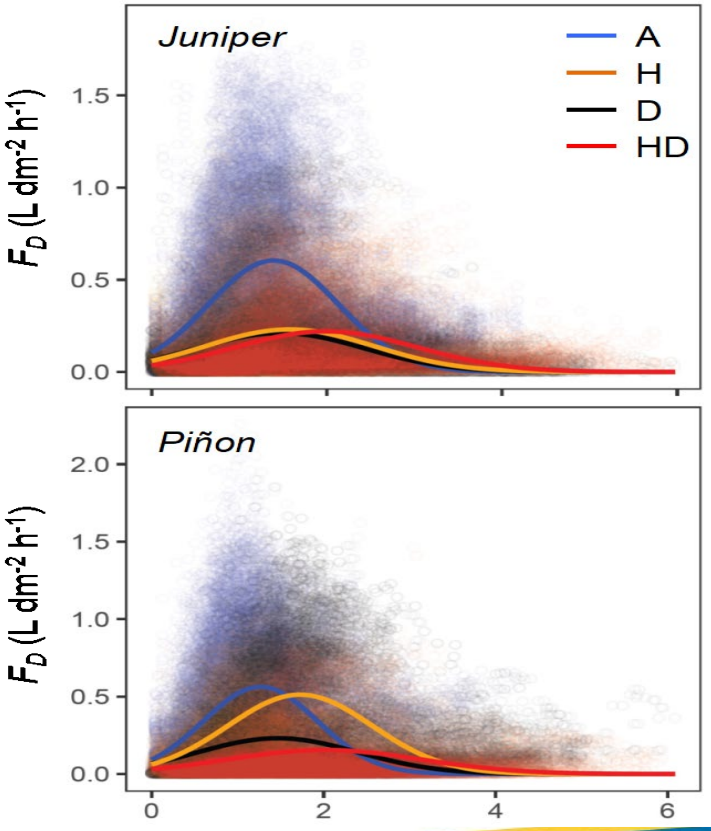


# Physiological acclimation



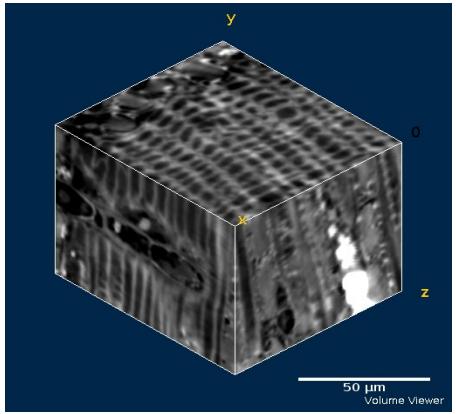
Stomatal opening adapts to atmospheric drought under warming

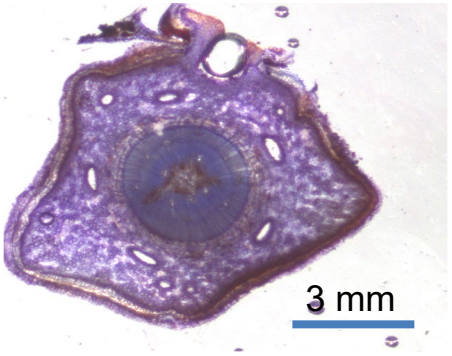



Grossiord et al. 2017 Plant, Cell and Environment

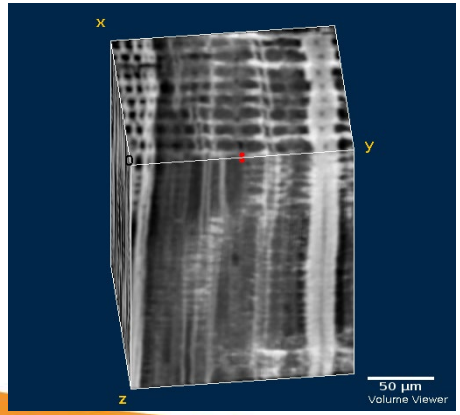
# Structural acclimation:

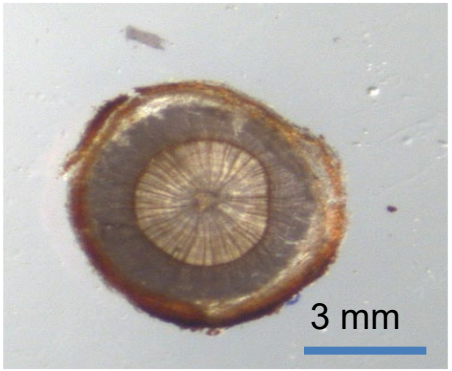
Pinus edulis



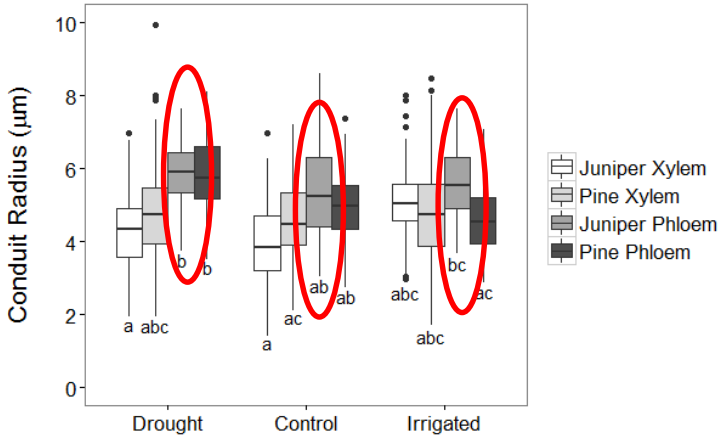




Juniperus monosperma



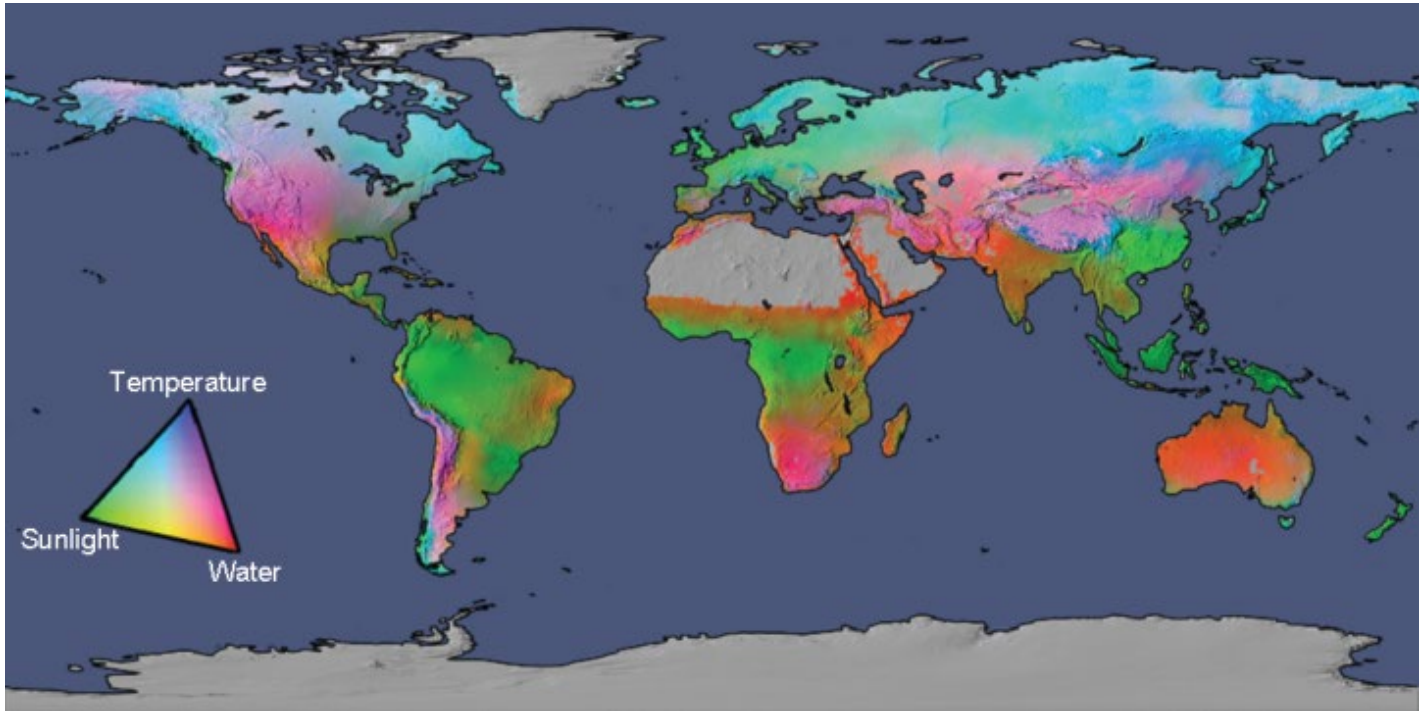

Carbohydrate transport capacity increases under drought in a desiccation avoiding species




Sevanto et al. 2018 PCE

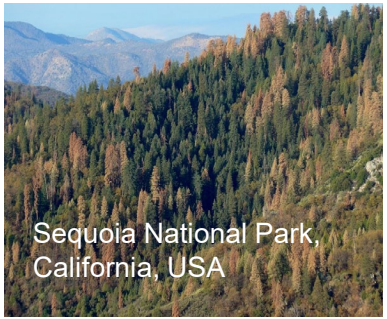
UNCLASSIFIED

# Some global aspects:



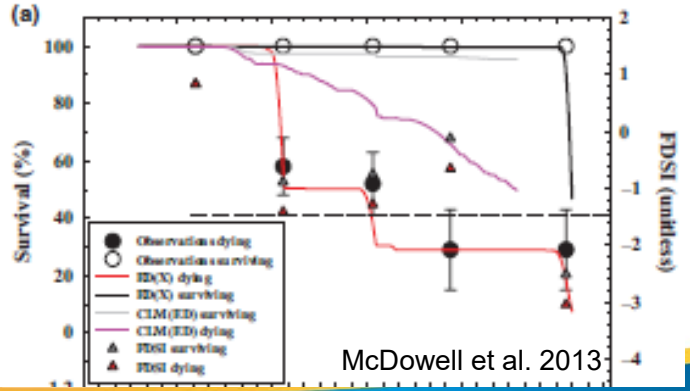

Boisvenue and Running GCB 2006

# Dying forests may look like this:

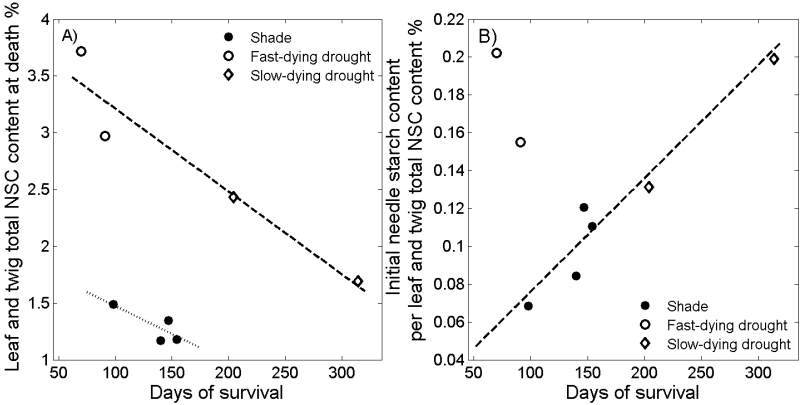


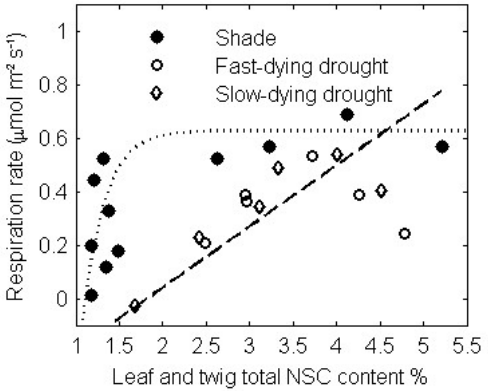



## Models predict collapse of the whole population:

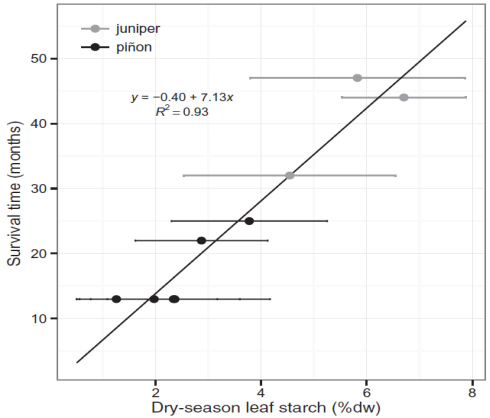


# What explains variation in individual survival time:




Sevanto et al. 2014 Plant, Cell and Environment

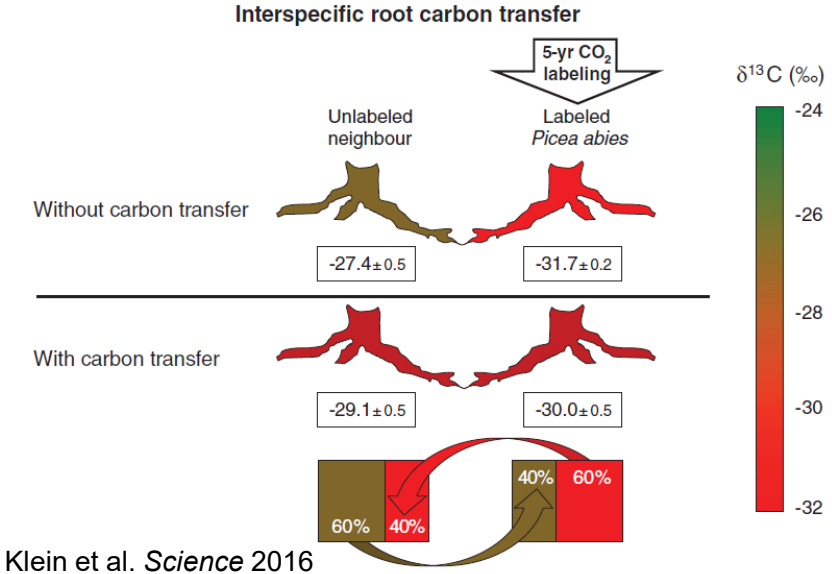



Dickman et al. 2014 Plant, Cell and Environment

# Maybe it's best to feed your support team?

## Trees trade carbon across species

"Forest is more than the sum of its trees"




Klein et al. *Science* 2016