Carbon and water are tightly linked in forests

Tree growth, water availability & use, and drought resistance are tightly linked

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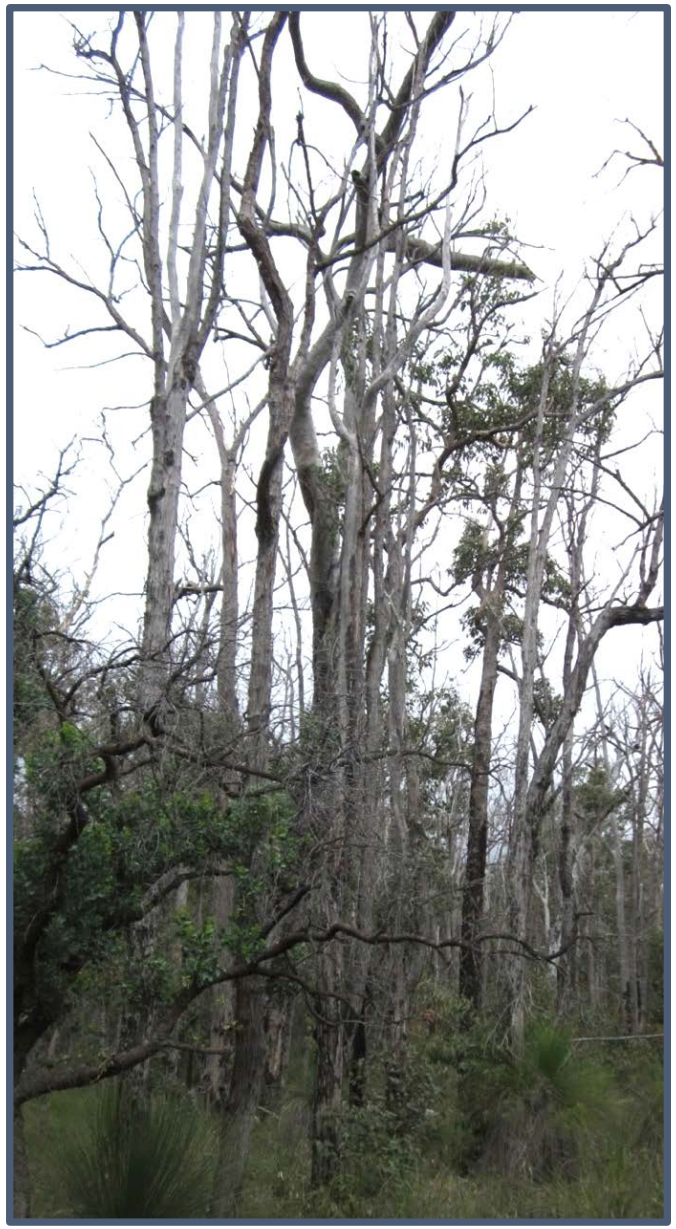
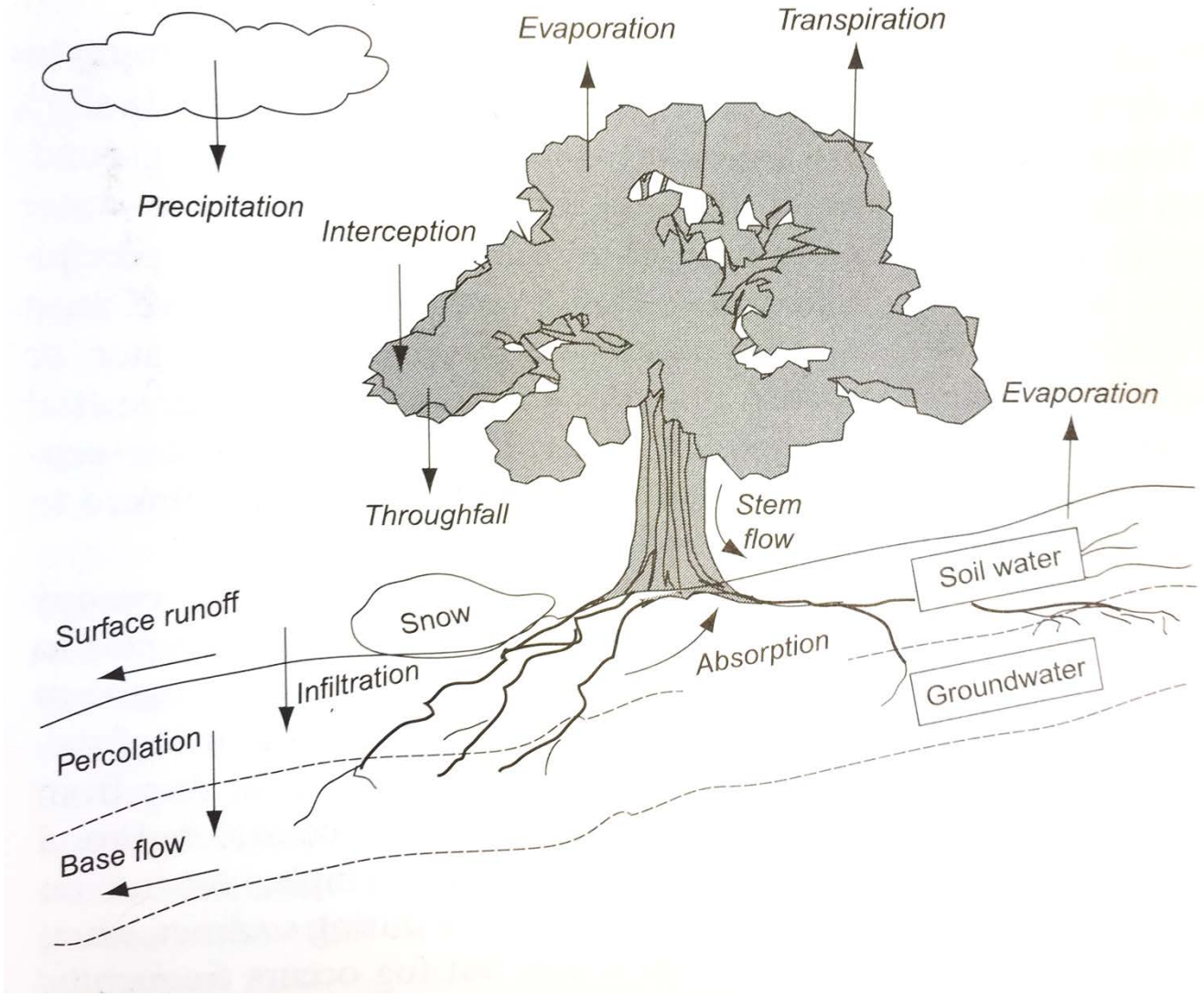


Eucalyptus marginata
Drought Mortality 2011-2012

Basics:

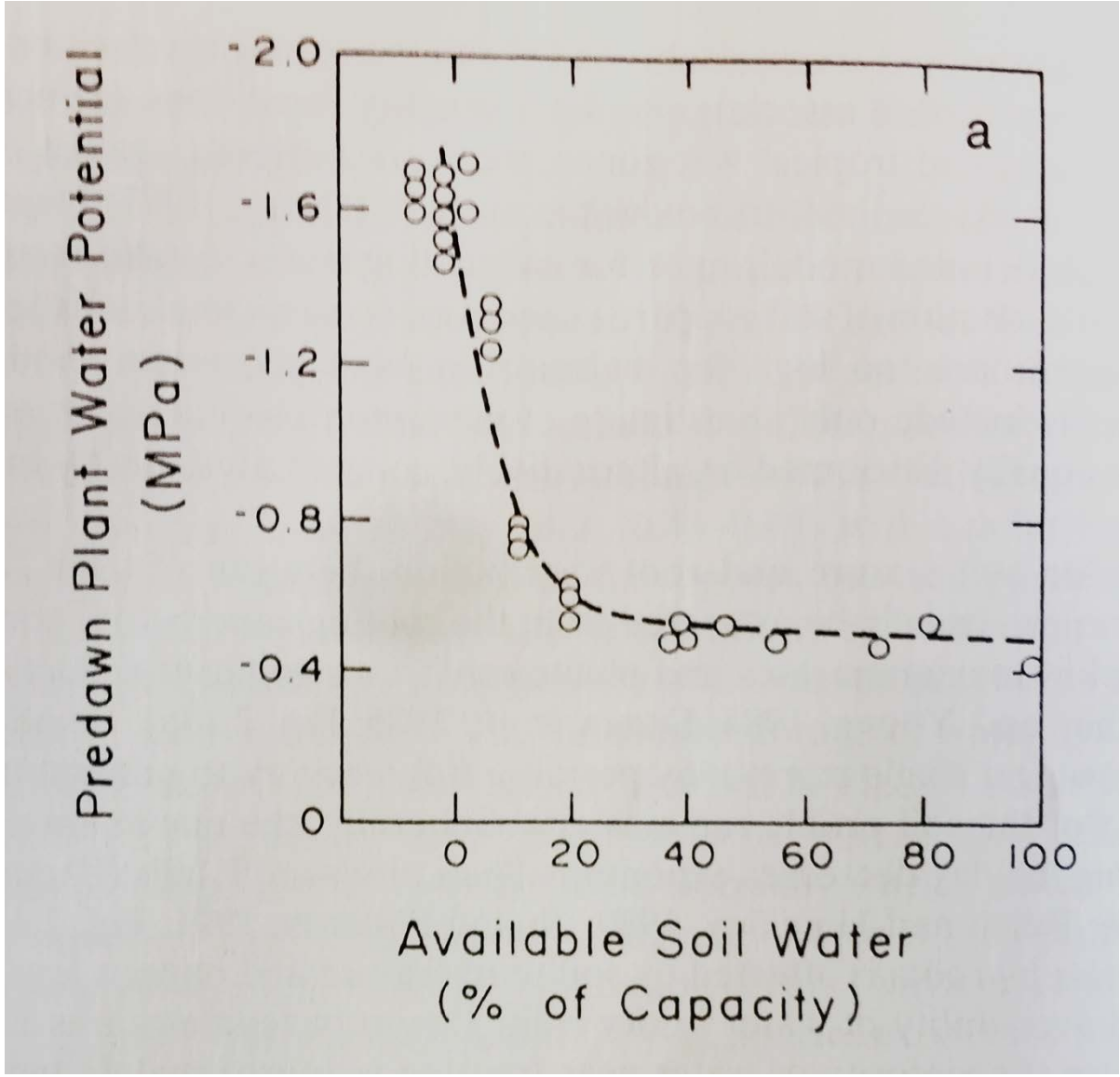
Plants need water to grow.

High soil water will promote the best growth if trees also have optimum nutrition, light and temperature.

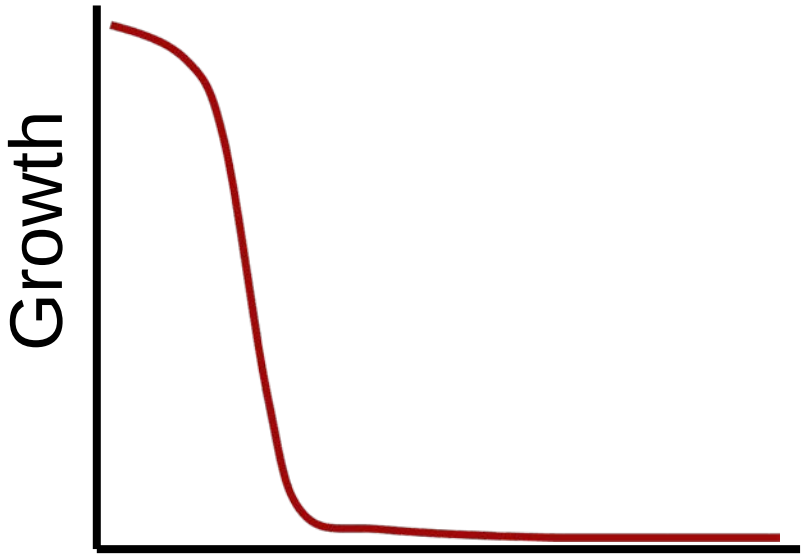


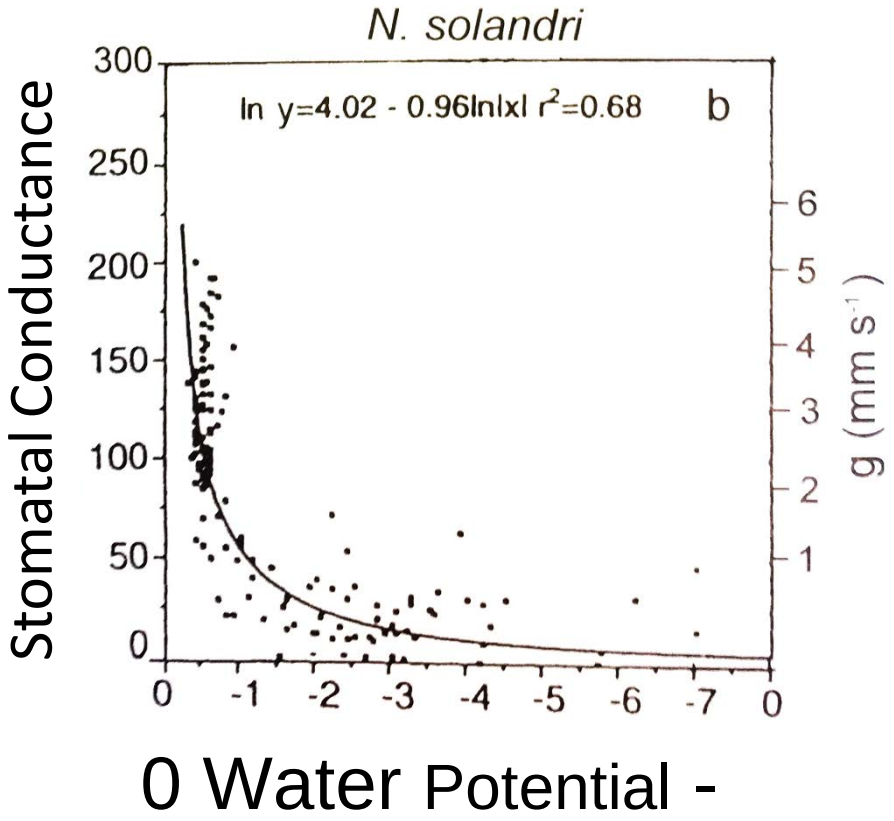
Soil water: %, amount (mm), or water potential

Tree growth and water transport depends on soil water potential.



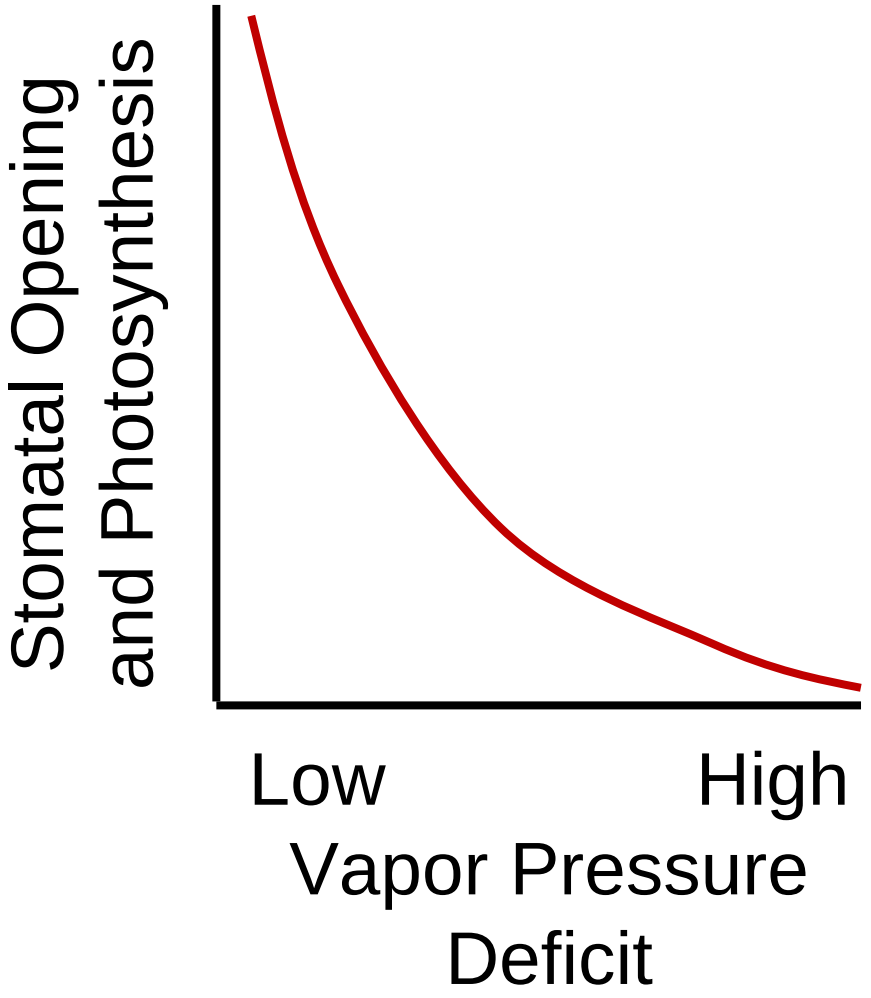
As soil water decreases, growth slows and then stops



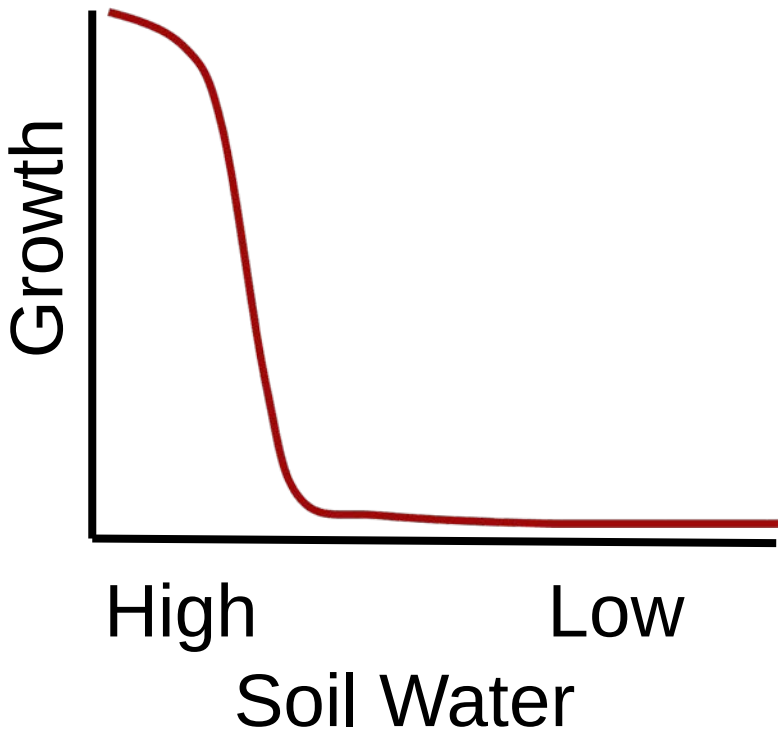


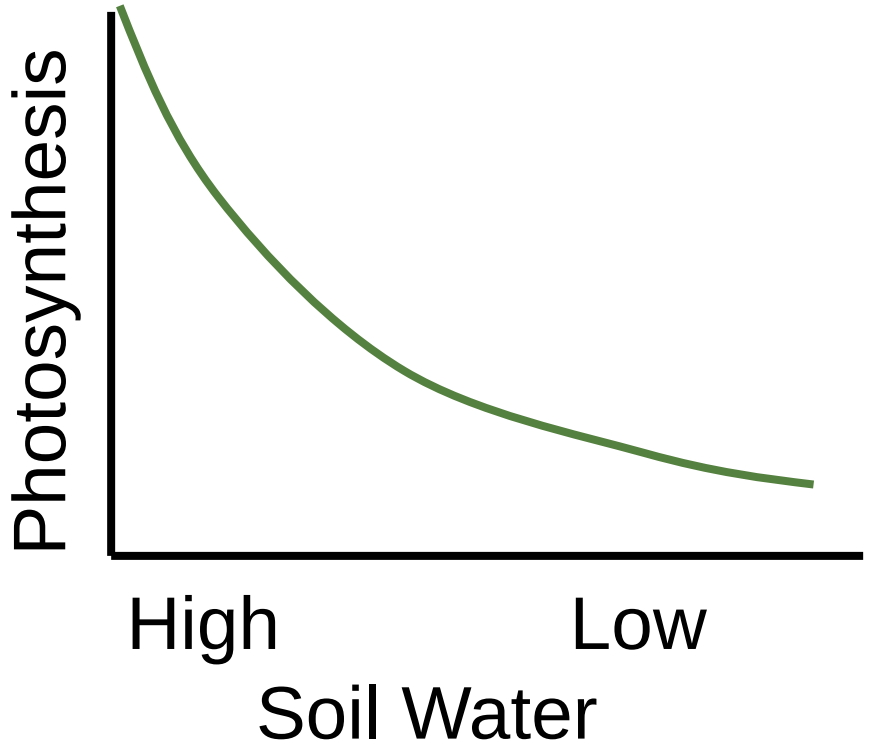
As soil water decreases, stomatal conductance and photosynthesis decrease

Low humidity (high vapor pressure deficit) also lowers stomatal opening, photosynthesis and transpiration



Growth is more sensitive to low soil water than photosynthesis



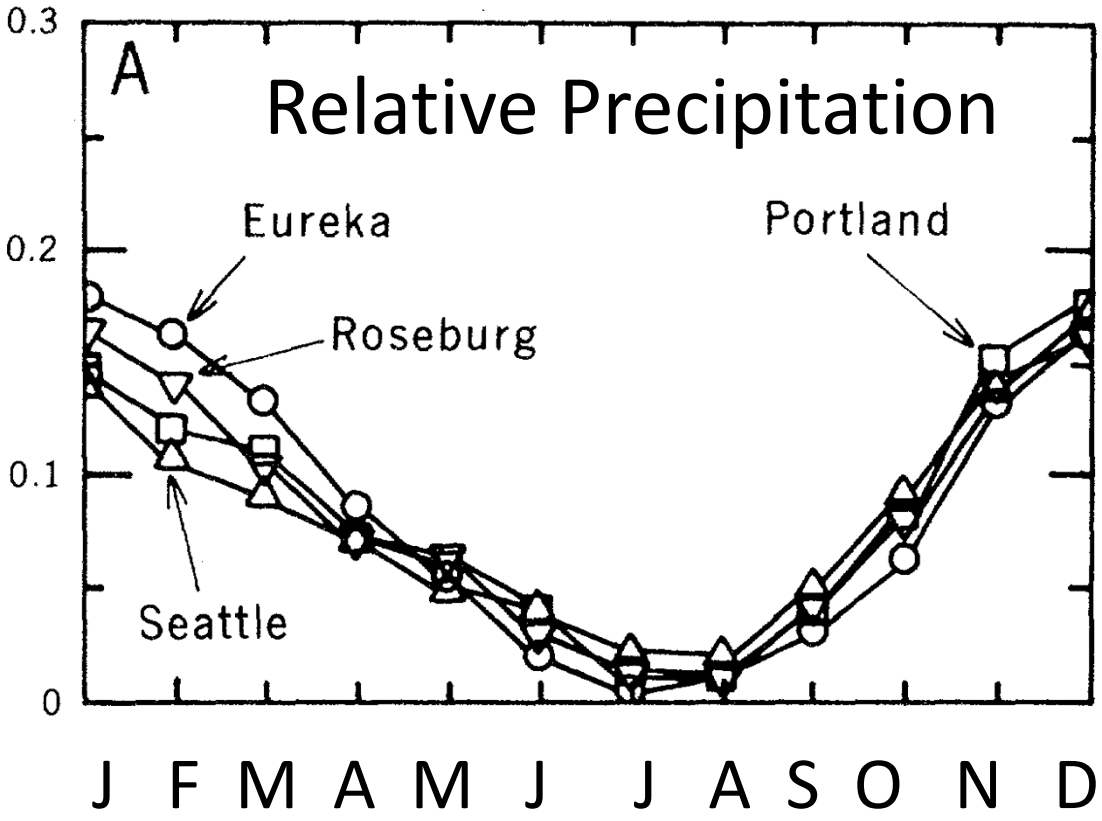


Soil water capacity depends on soil depth and soil texture

Deeper soils hold more water
Clay soils hold more water
Rocks hold little water

Soil water content depends on capacity and precipitation *minus* evapotranspiration

Reduction of soil water through the growth season depends on leaf area, humidity and light, and soil water capacity.



Leaves pump water into the air better than evaporation from litter or soil

Waring and Franklin 1979

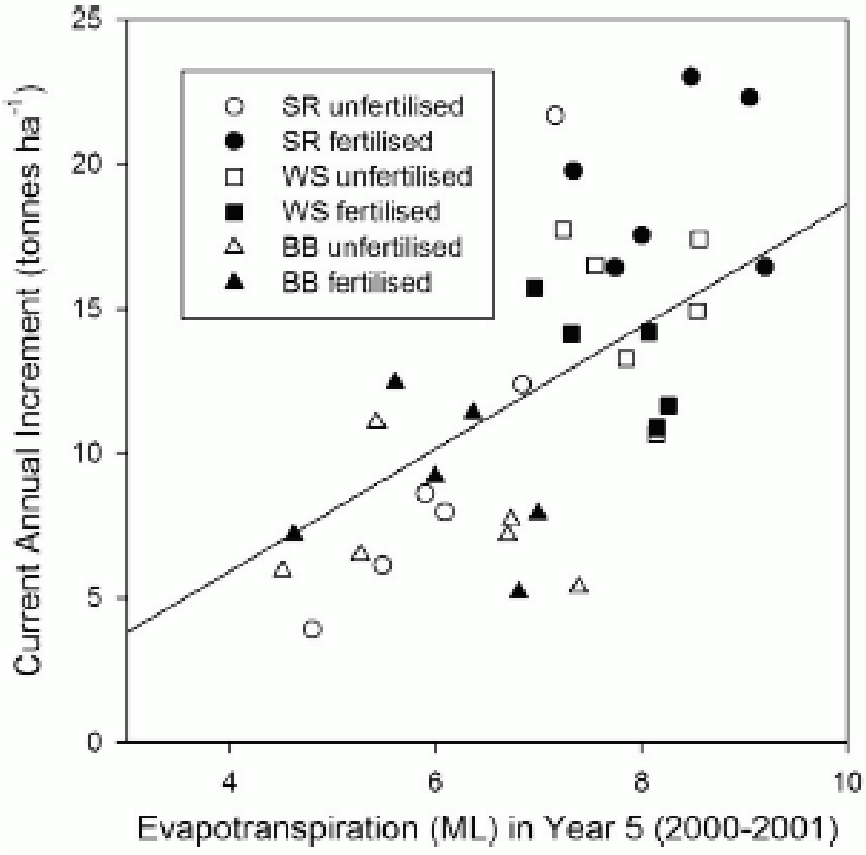
Larger trees grow less per unit of leaf area and use less water—but store more carbon (Ryan and Yoder 1997)

Keeping the big trees happy is low cost carbon storage

Fundamental links in trees' carbon and water cycles: changes in wood growth (and carbon storage) will be accompanied by changes in water use

Wood growth/water use is fairly stable

High growth = high water use
Low growth = low water use

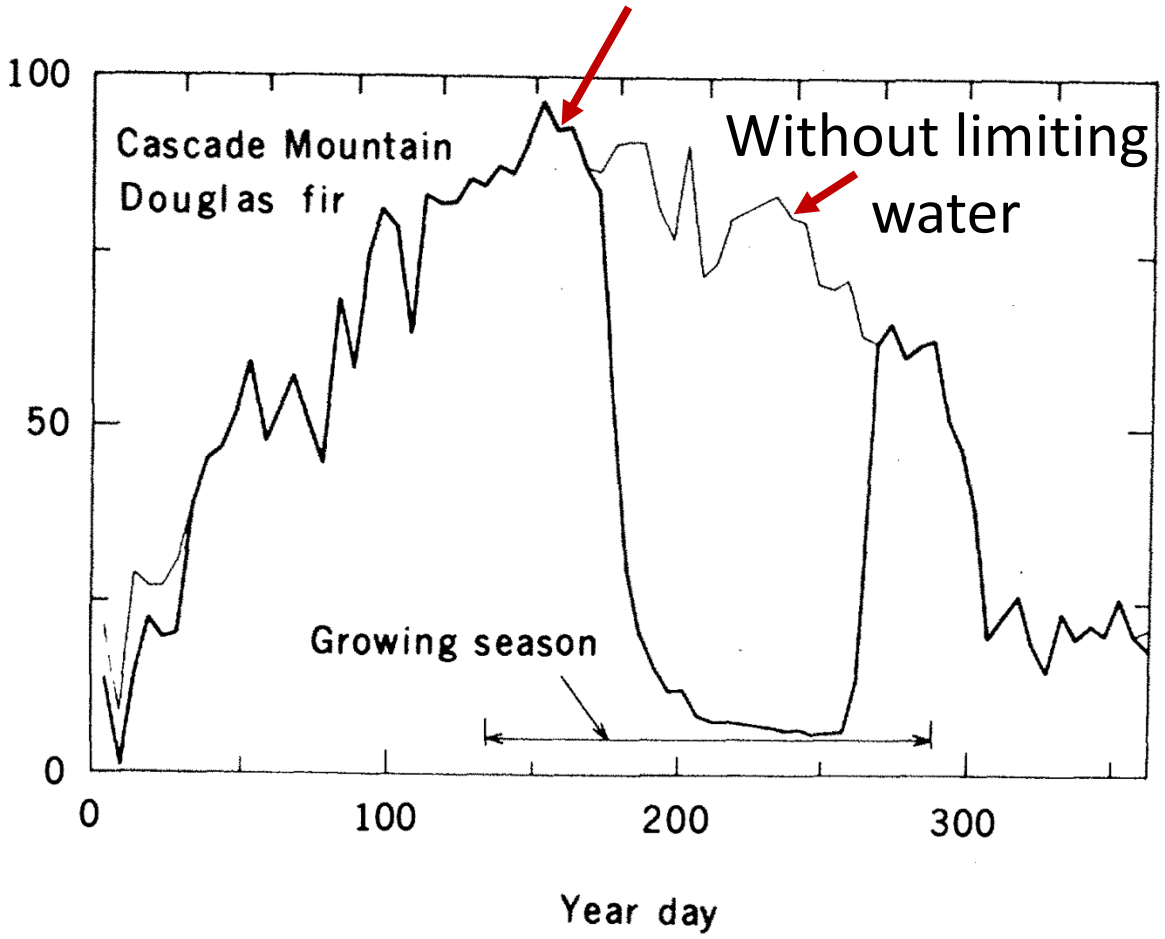


White et al. 2014 FEM

Drought resistant trees or stands are slower growing trees or stands.

Wood characteristics make drought resistant trees able to withstand low soil water without dying. But, that wood does not transport water well.

Modelled photosynthesis



Waring and Franklin 1979

In the PNW, soil water is optimum when temperatures and light are not, and low when light and temperature are optimum

Most growth occurs in spring – water, temperature, and light

Silviculture can work with these physiological constraints to build resilience by thinning to reduce stand density and leaf area.

Thinning trades off lower stand growth with more growth/tree on fewer trees.

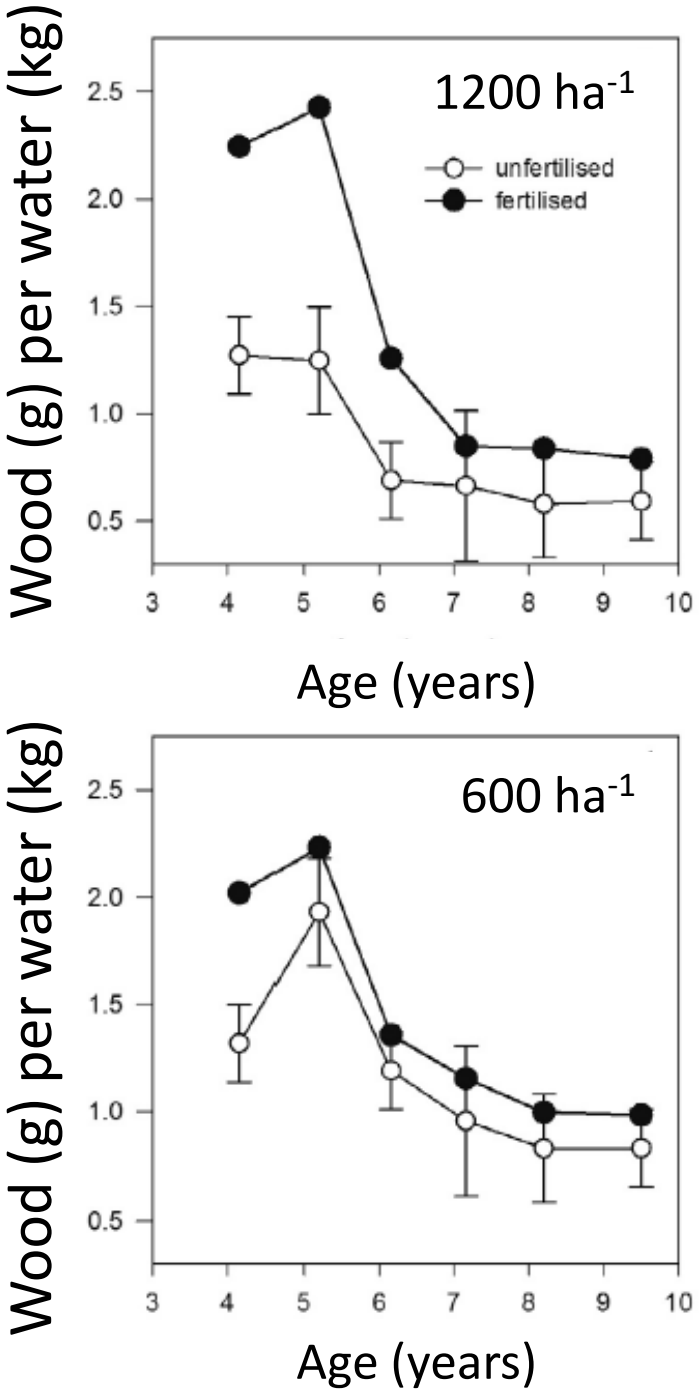
Thinning

- Gives the fewer trees more water, light and nutrients
- Extends growth longer into dry season (soil water lasts longer)
- Increases the drought resistance of the fewer trees

Silviculture can also increase nutrition and reduce competing vegetation

Both increased nutrition and reduced competition increase resources of light, water and nutrients to remaining trees

Increases tree growth & wood/water



White et al. 2014 FEM

These practices

- Increase photosynthesis/tree
- Switch carbohydrates from below ground and ephemeral carbon stores to a longer-lasting carbon storage in wood
- Increase water/wood (a bit)

Any selection for water use efficiency at leaf level means slower growth at the tree and stand level

Future tree improvement might select for rapid leaf shedding and canopy rebuilding during drought and recovery

Conclusions

- Tree growth and water use are tightly linked
- Thinning and competition control can increase resilience in a summer-drought ecosystem that is getting warmer (and perhaps provide a bit more water)