

Forest Restoration

An Ecophysiological, or Seedling's Perspective



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NurseryToForest Solutions

Foresters know how to grow trees!

Do foresters know how trees grow?

Silvics & Ecophysiology

Silvics

Principles underlying the growth and development of single trees and of the forest as a biological unit.



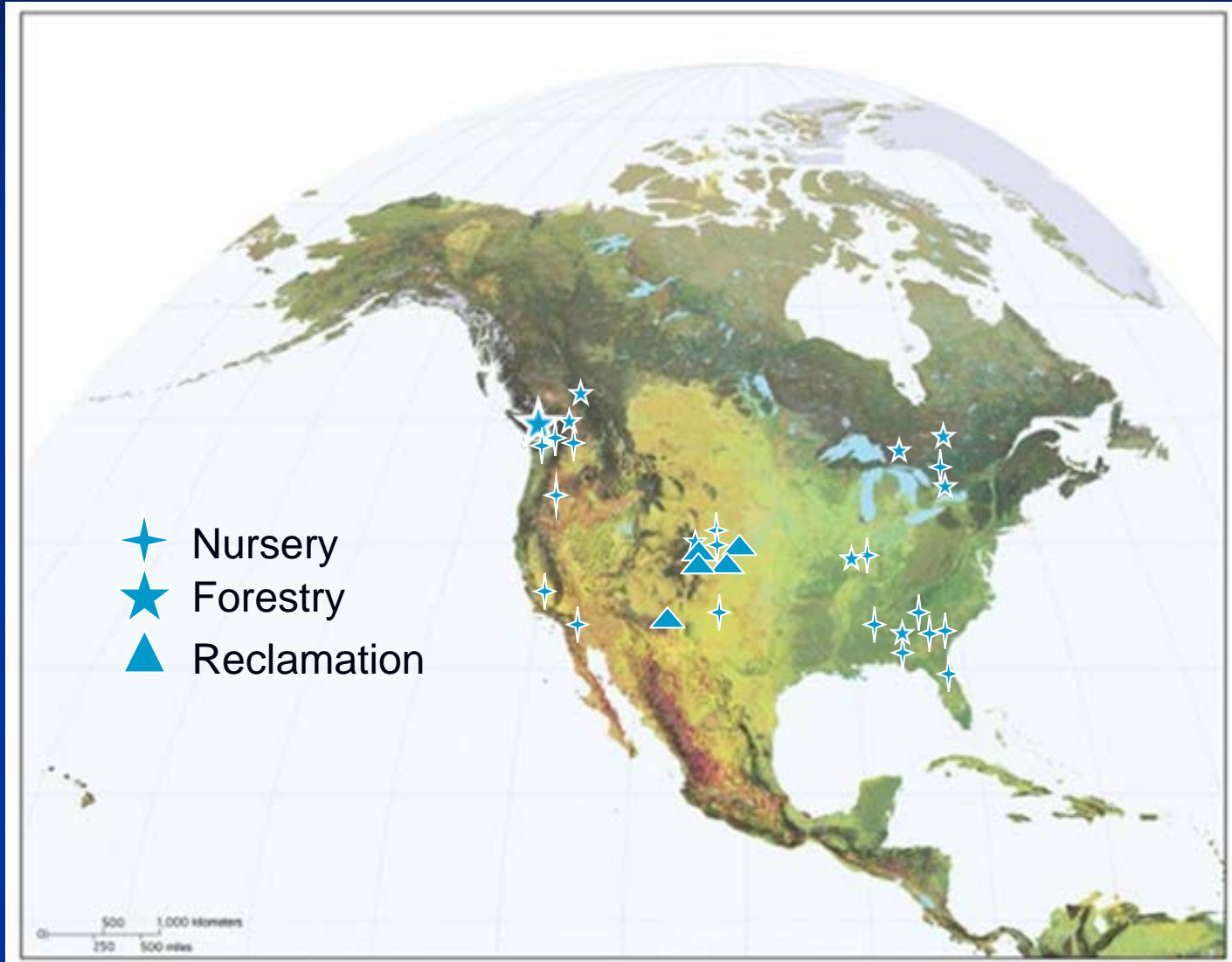
Ecophysiology

Physiological and morphological processes of plants in response to the surrounding environment.

Ecophysiological Approach

“...remedies are usually found at the whole plant level in terms of silvicultural treatments.” (Kramer 1986)

Programs across North America

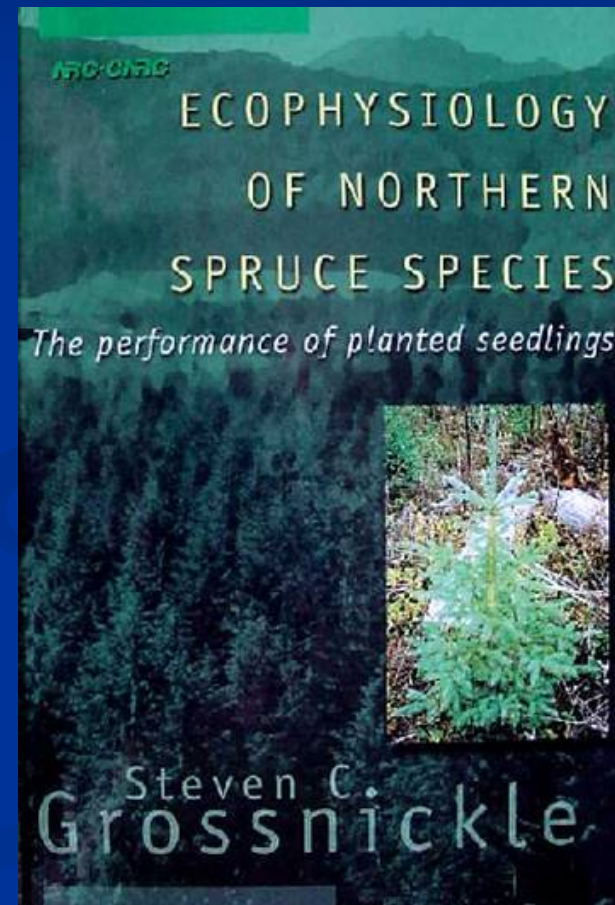


Information Sources

Provide practitioners and researchers with a seedling's view of regeneration silvicultural practices on field performance.

Book Available at NRC Press
Publications @

https://www.researchgate.net/profile/Steve_Grossnickle

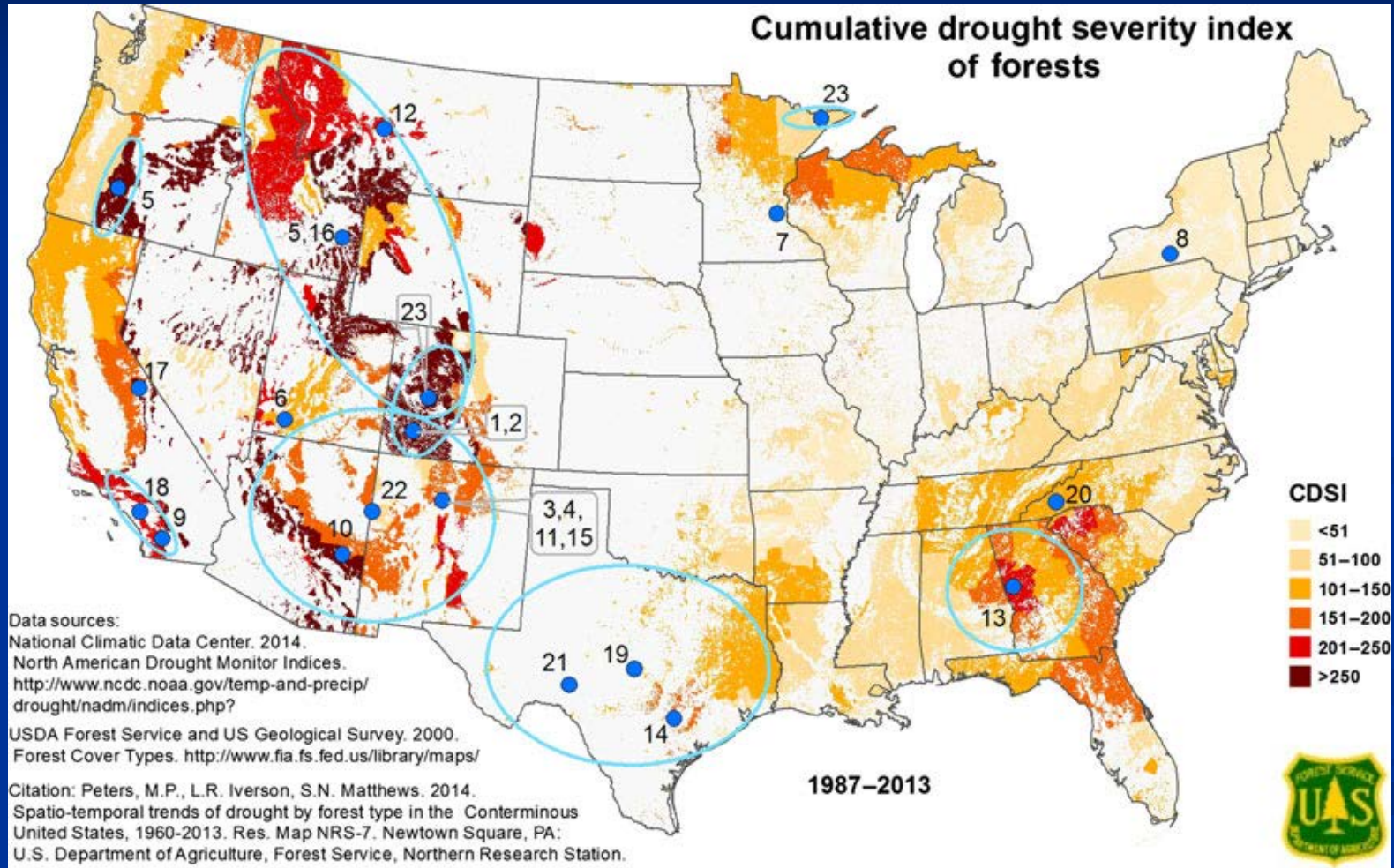


Climate Change

“...recent studies document more rapid mortality under hotter drought due to negative tree physiological responses...”

(Allen et al. 2015)

Regional Shifts



Environmental Conditions

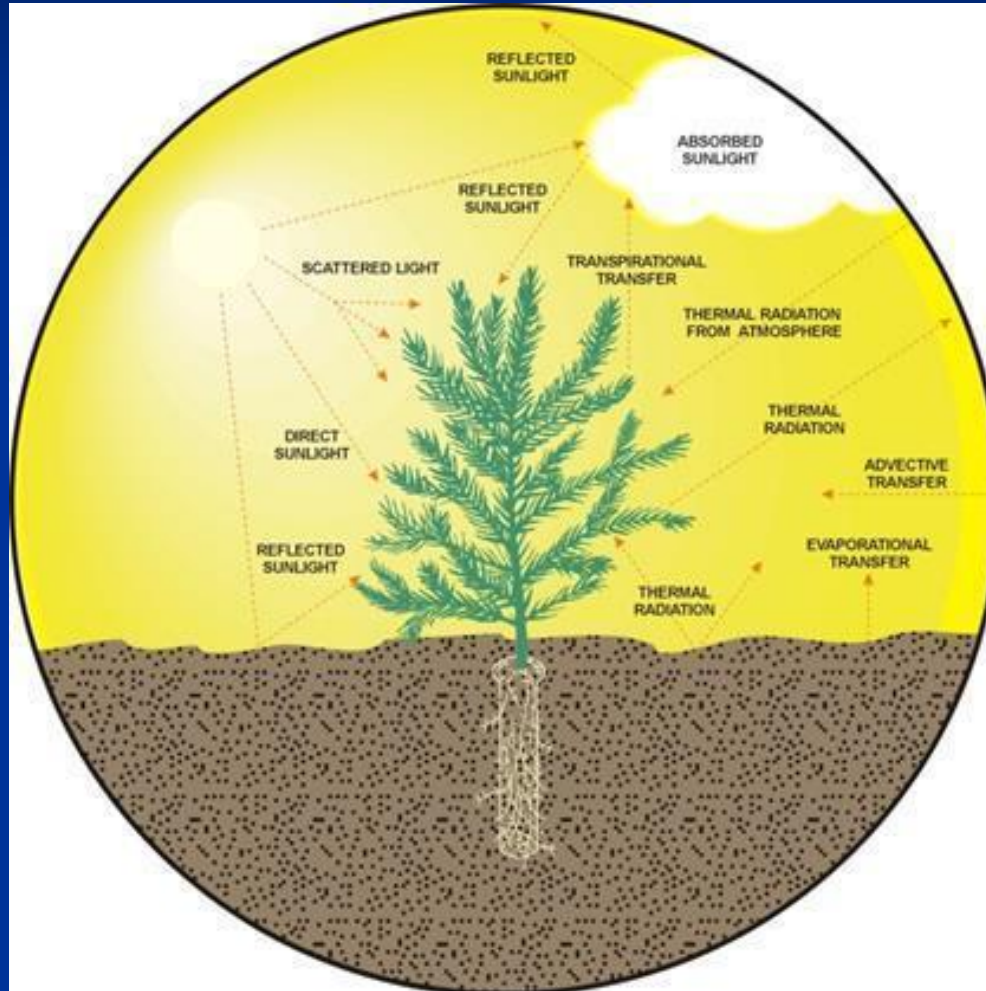


Forest Regeneration Site

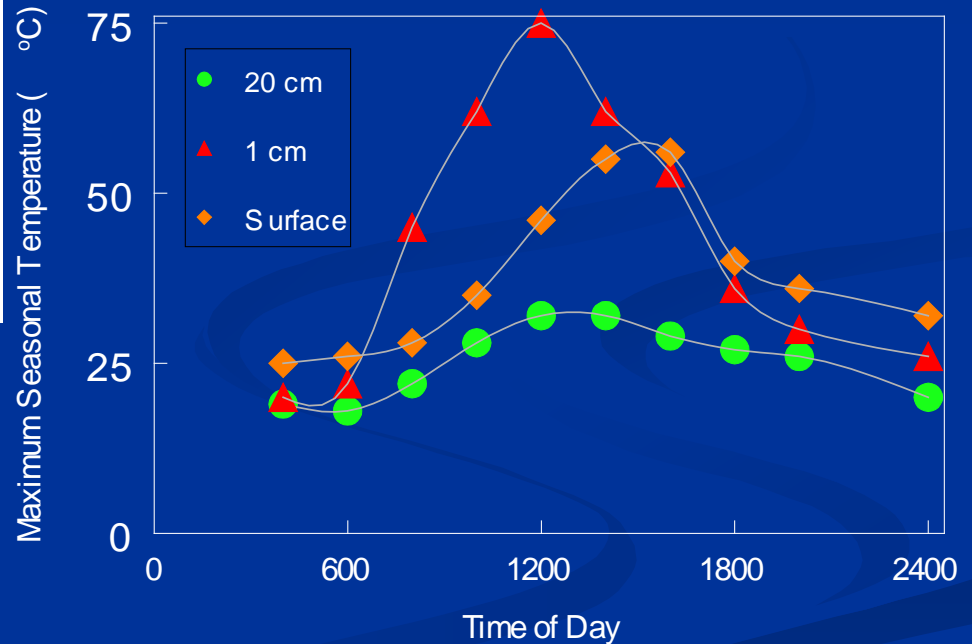
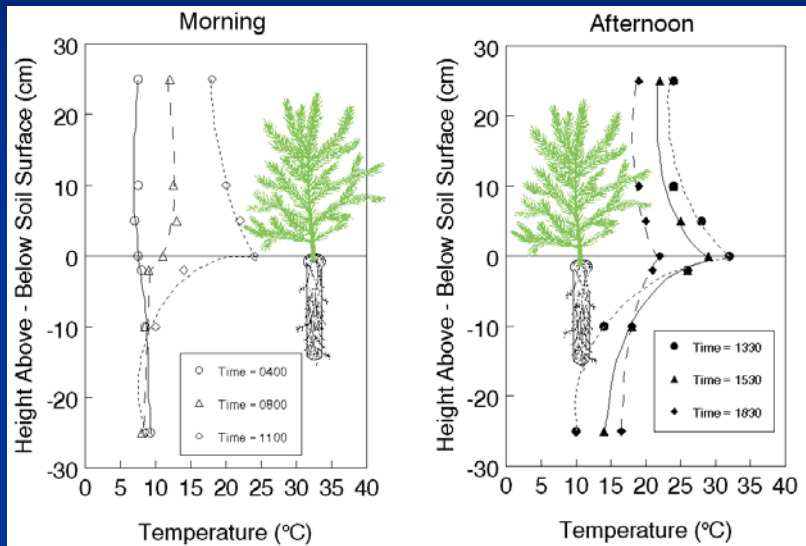
- Initially greater incoming solar radiation
- Greater air temperature extremes
- Increased evaporative demand
- Increased windspeed

- Initially higher soil temperatures
- Excessive soil moisture in poorly drained soils
- Inadequate soil moisture in well drained soils
- Increased nutrient availability in the soil solution

Energy Exchange



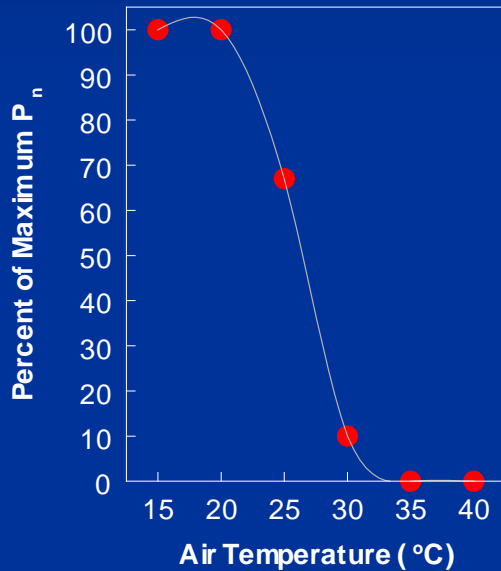
Seedling Environment - Temperature



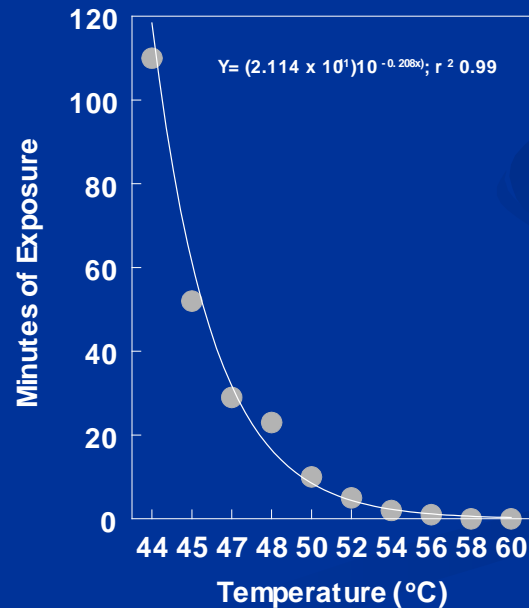
Kolb & Robberecht 1996

Seedling Response – Temperature Duration, Timing & Intensity

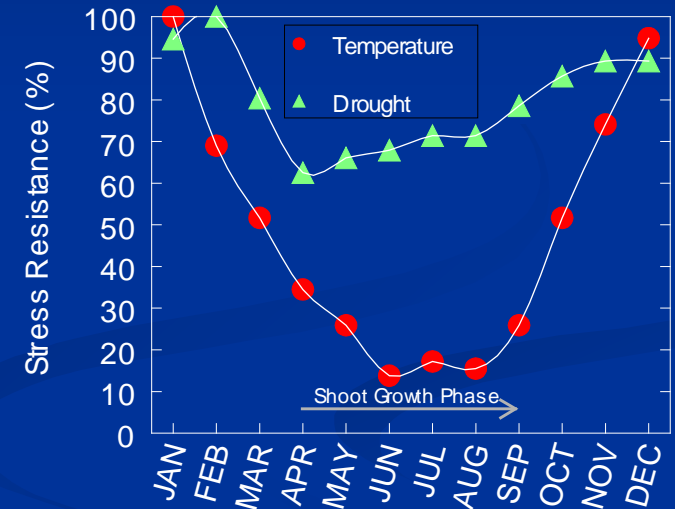
Intensity



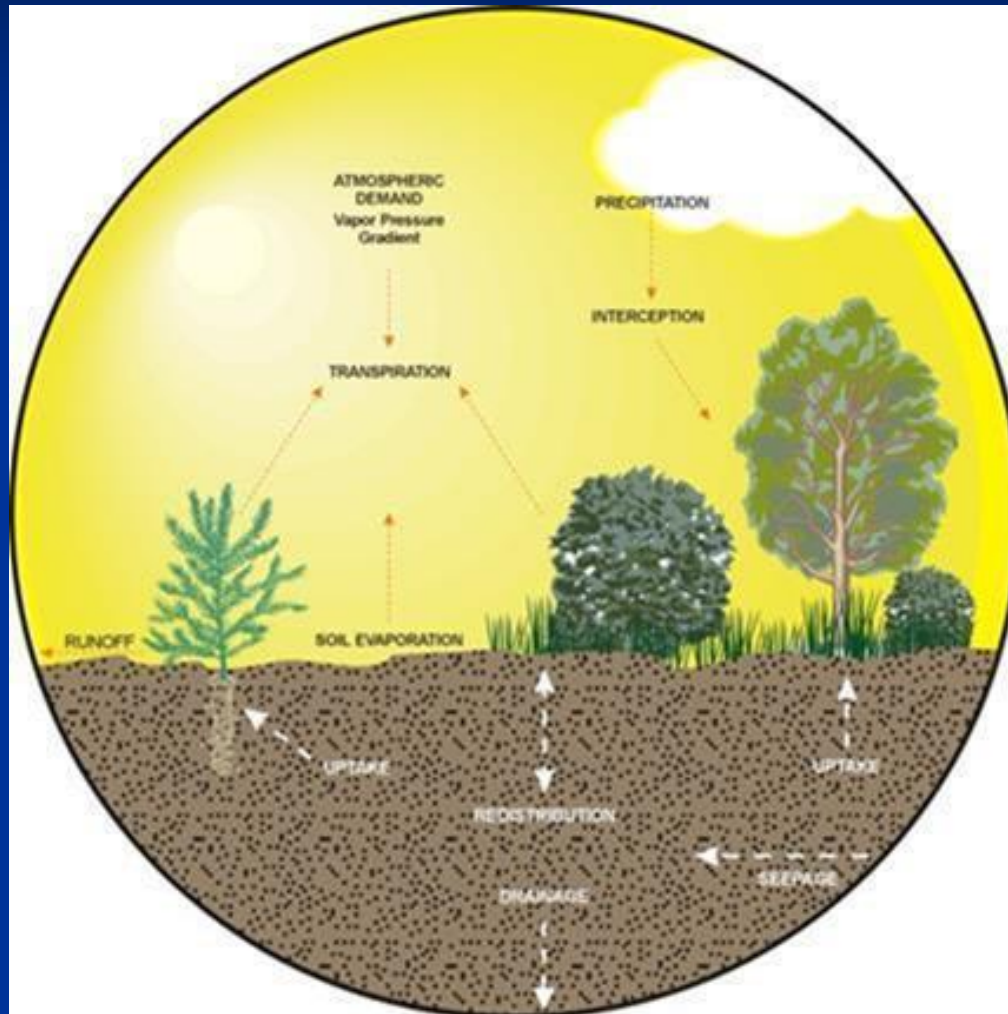
Duration & Intensity



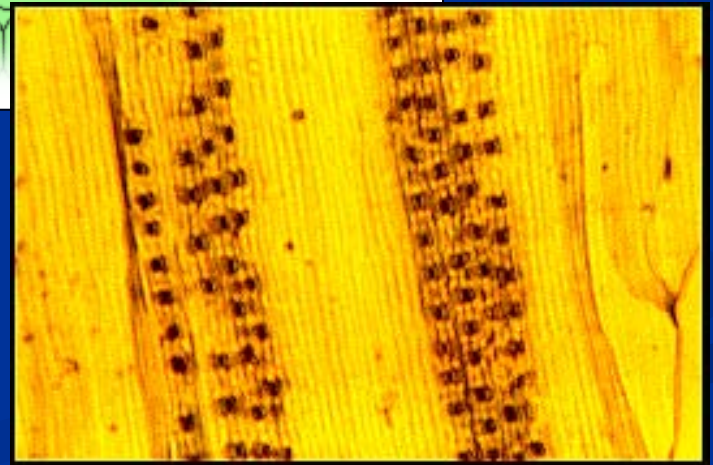
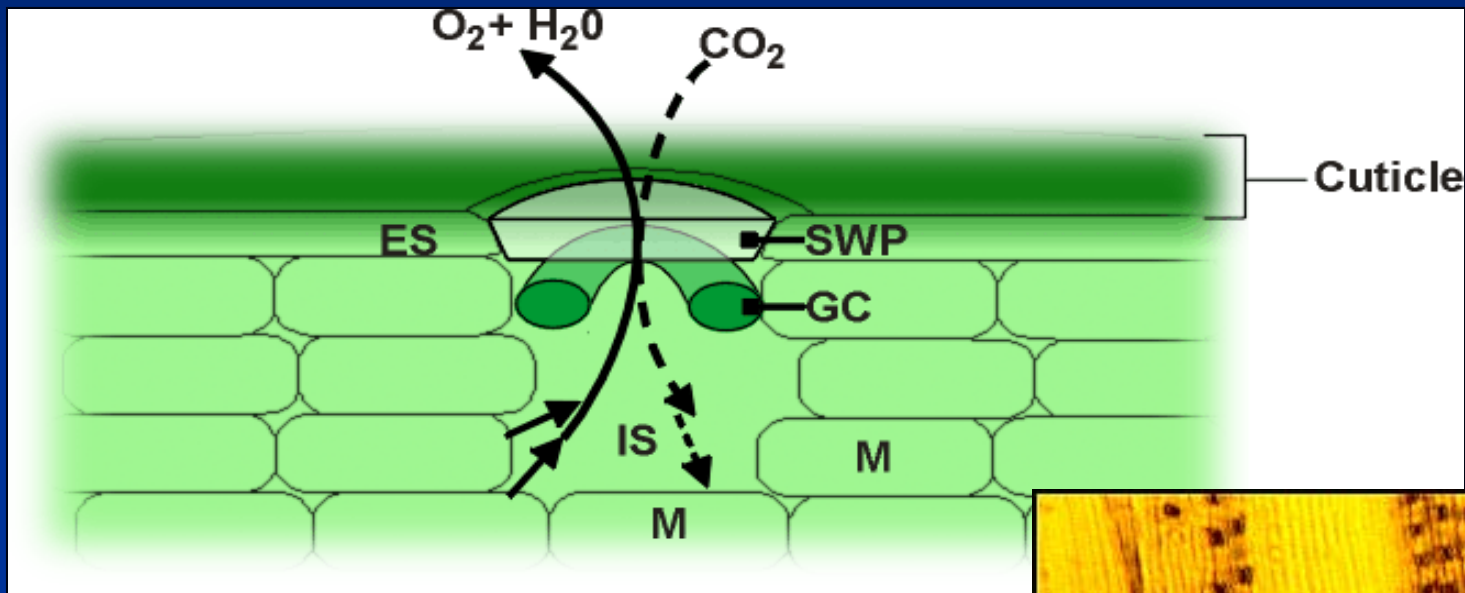
Timing



Hydrologic Cycle

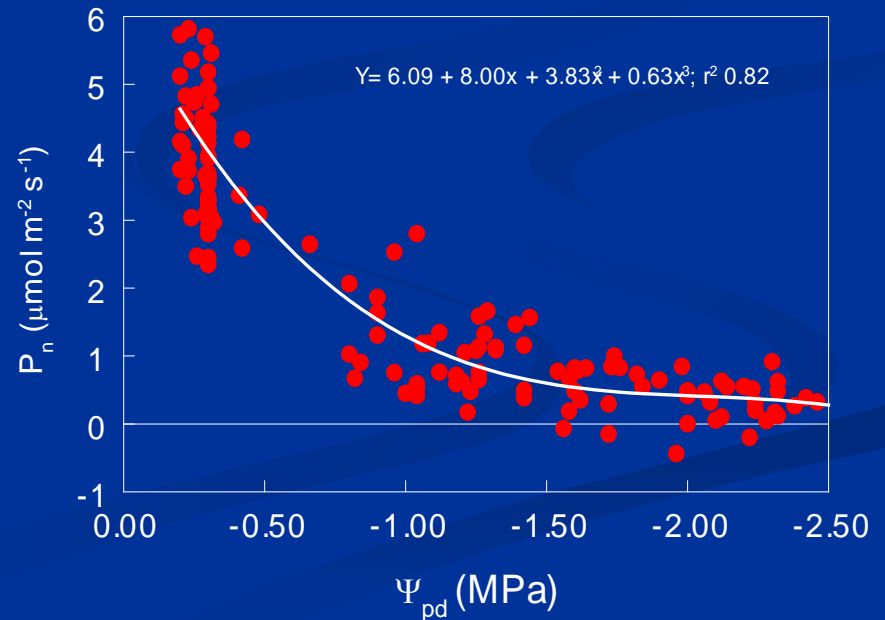
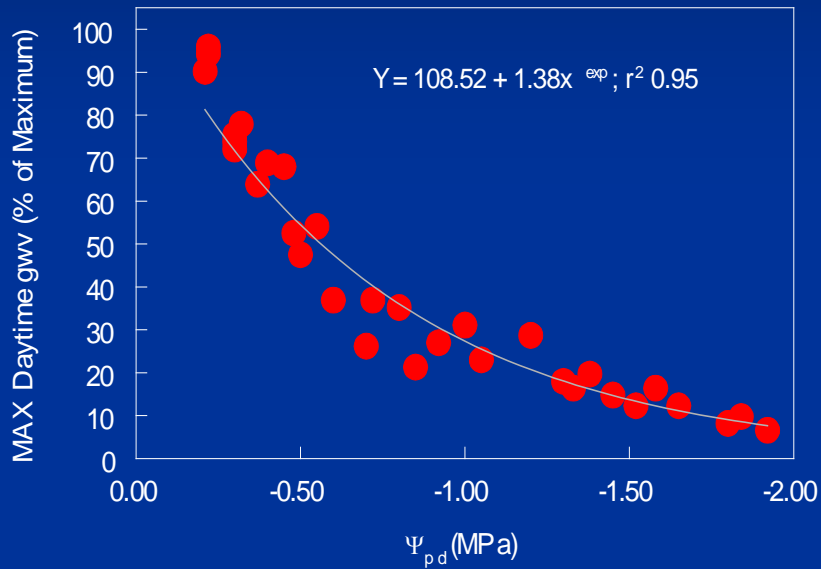


Location of Carbon Uptake & Water Loss

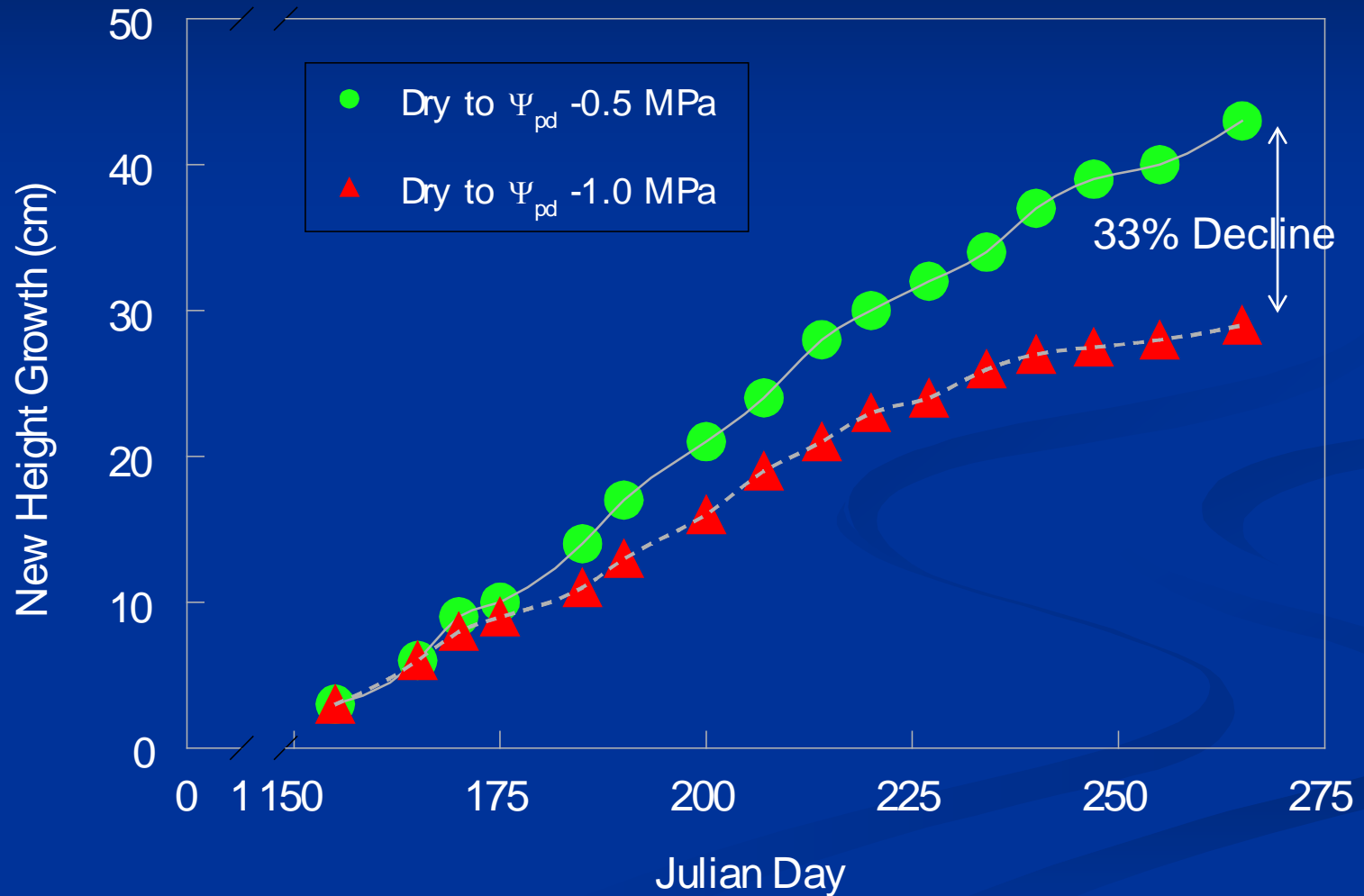


Response to Drought

Gas Exchange Response

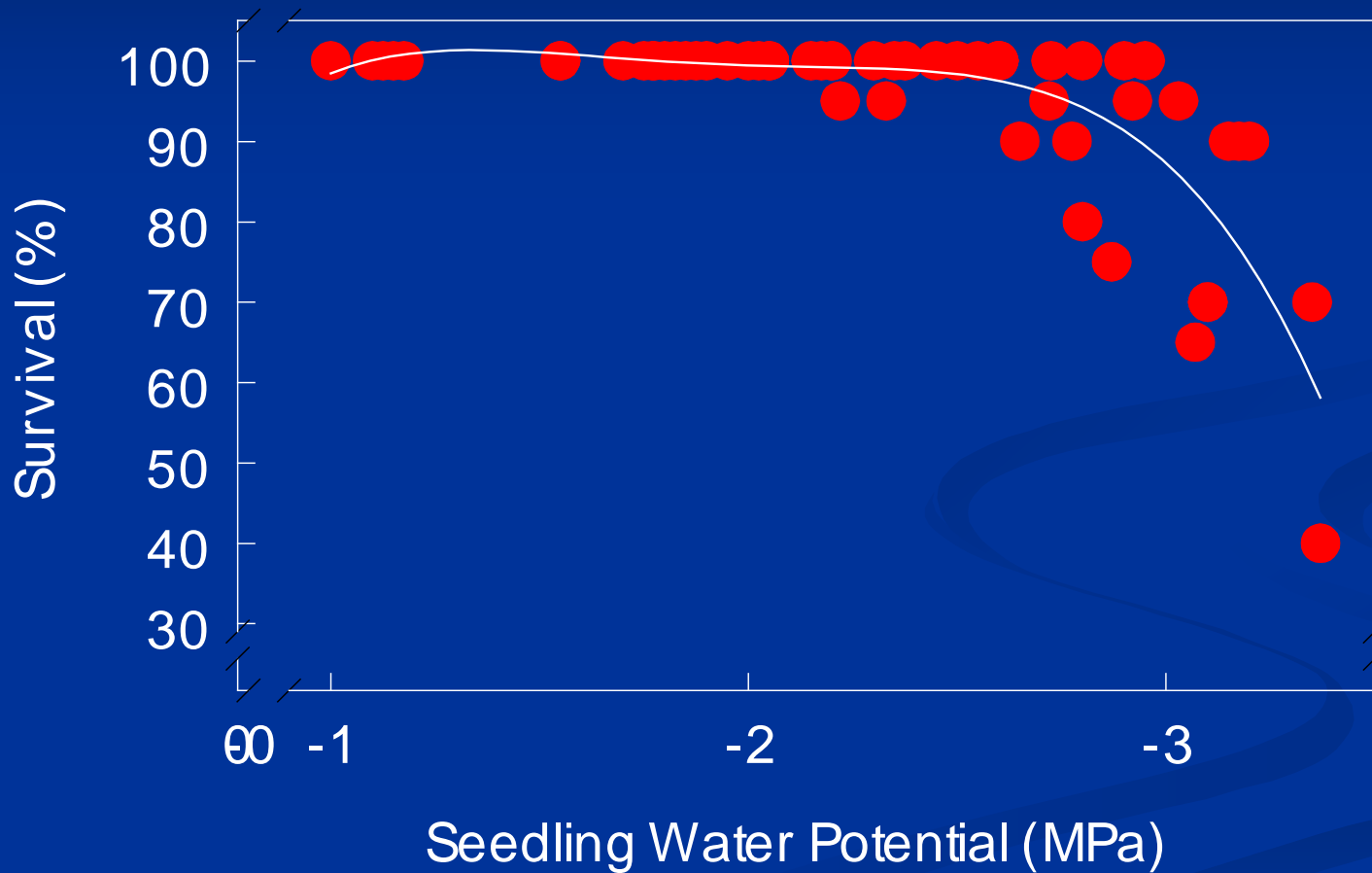


Response to Drought *Growth*



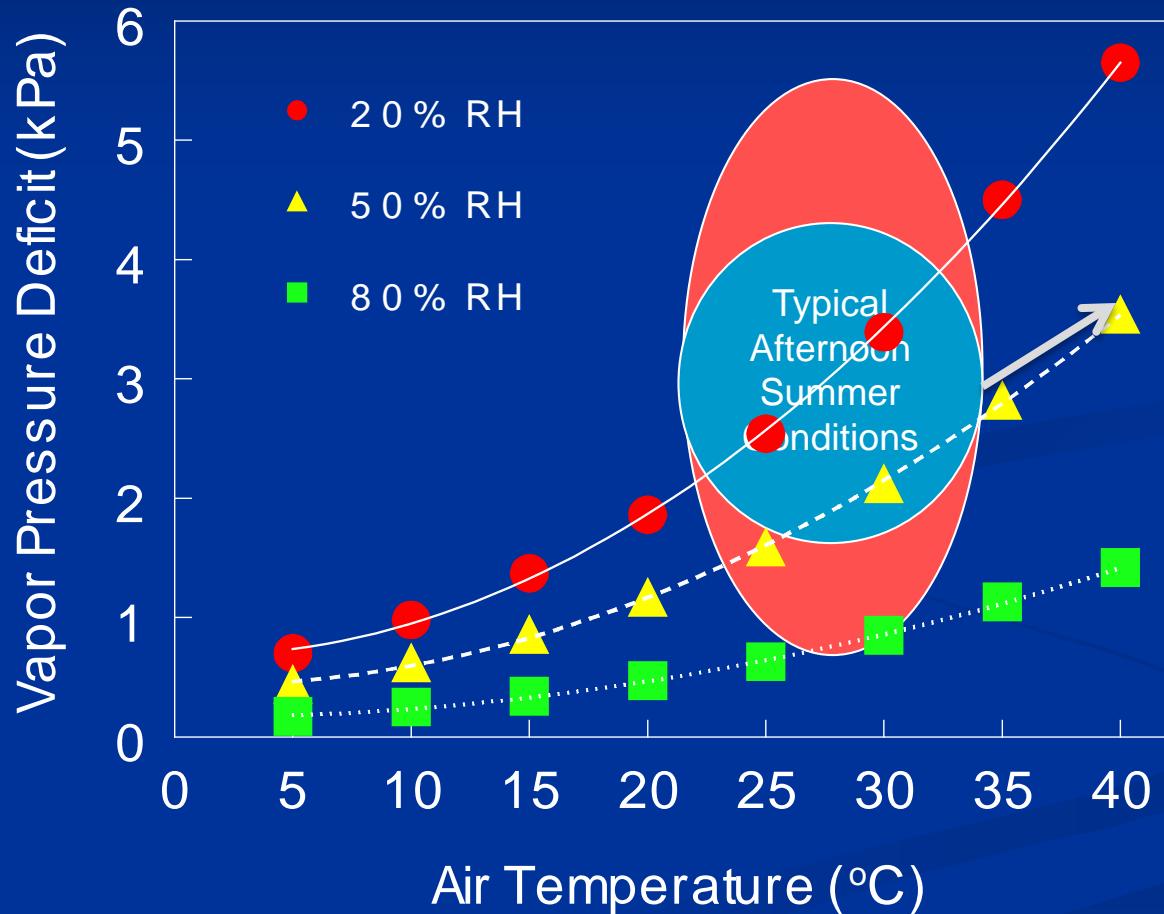
Response to Drought

Lethal Level



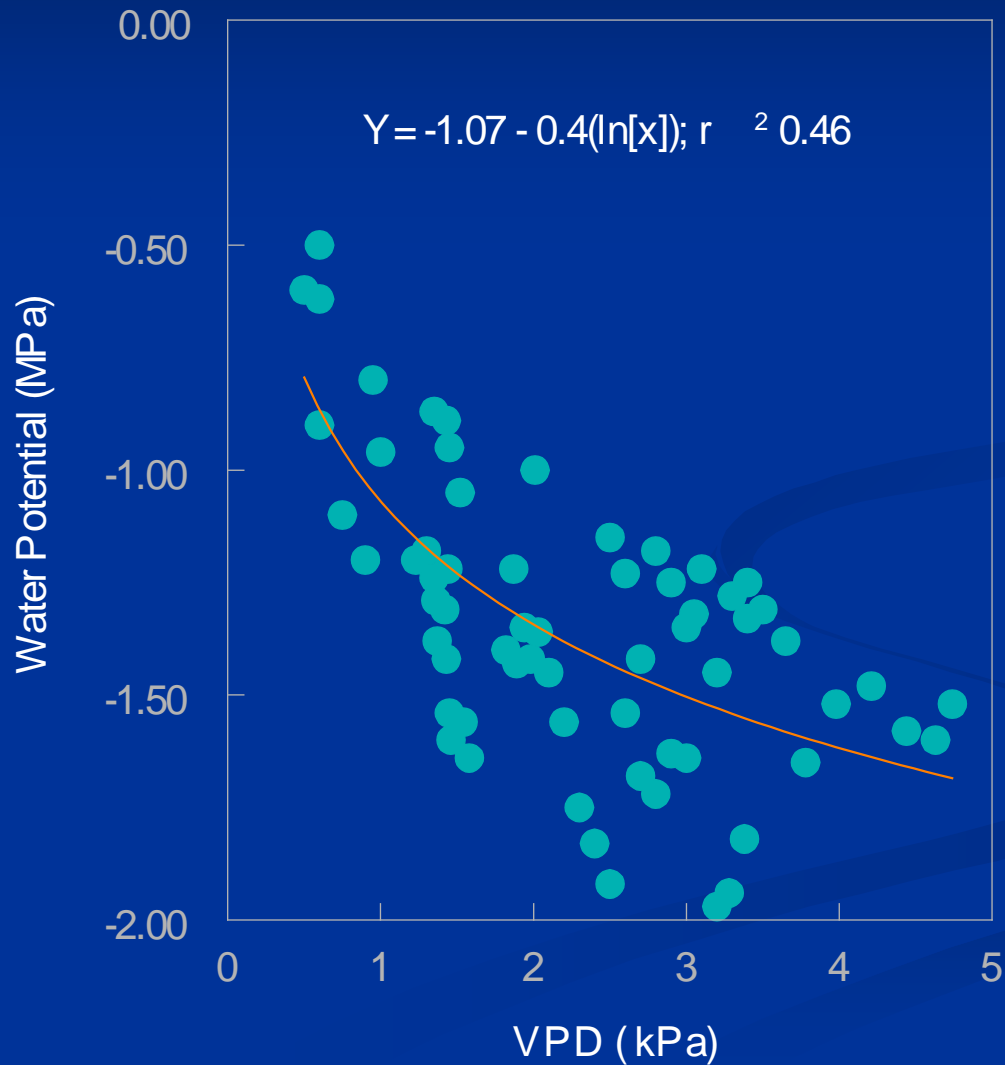
Atmospheric VPD

Drying Power of Air



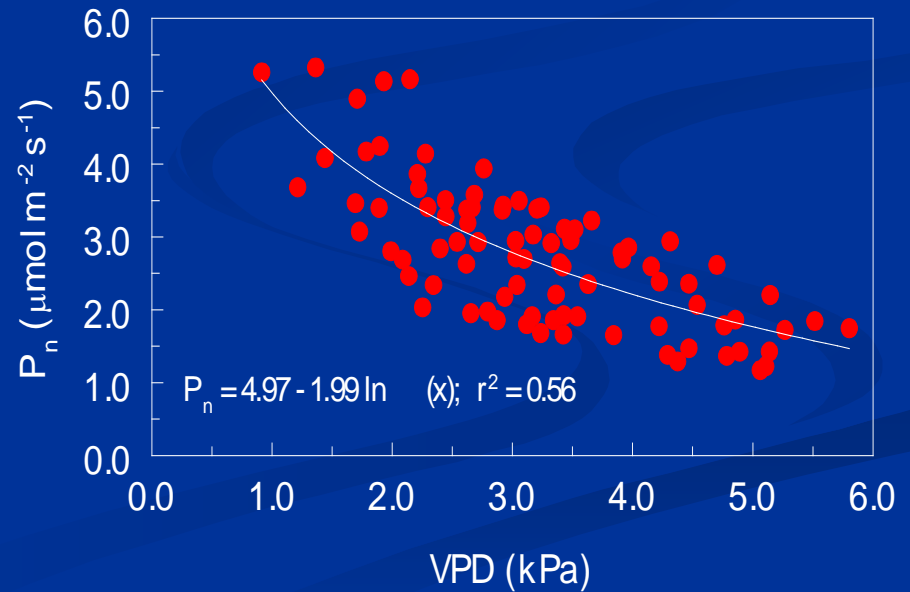
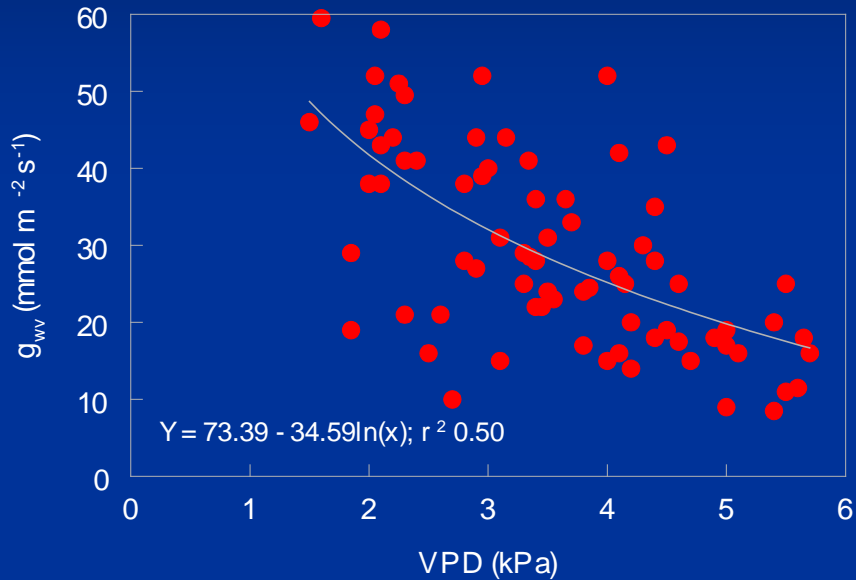
Response to VPD

Water Status



Response to VPD

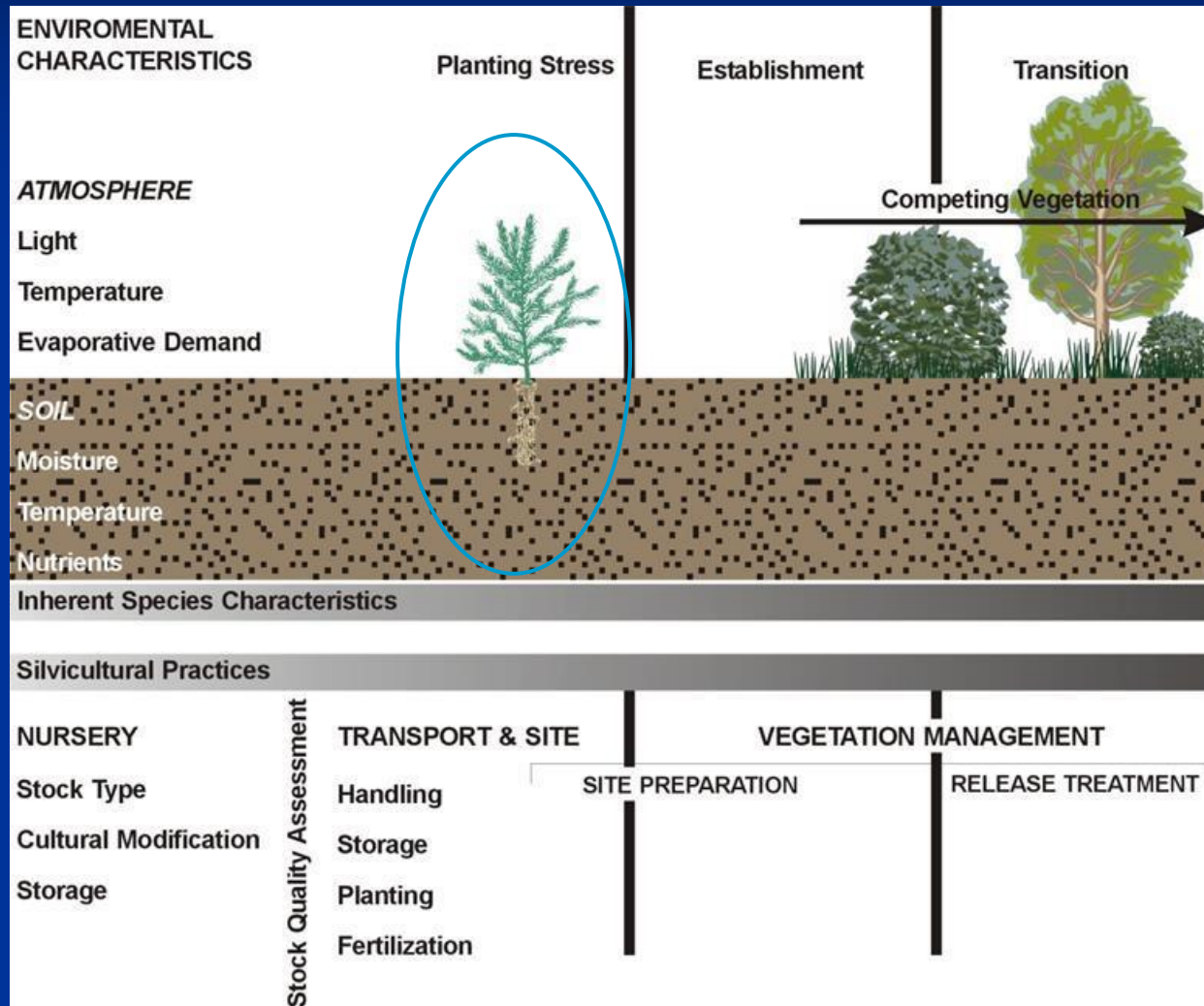
Gas Exchange Response



Summer Heat & Drought

- Seedlings can be exposed to limiting or 'killing' temperatures.
- Drought comes in the form of:
 - Low soil water availability
 - High atmospheric VPD
- Drought exposes seedlings to:
 - Water stress
 - Reduce gas exchange
 - Limited growth
 - Death

Forest Regeneration Process



Understanding Plantation Failure



“An understanding of the causes of plantation failure is necessary if there is to be an improvement in large scale reforestation work...”

Rudolf (1939)

Seedlings can grow anywhere!



Seedlings don't always grow where we plant them!

The greatest seedling mortality occurs in the initial years after planting and is due to planting stress (Grossnickle 2005).

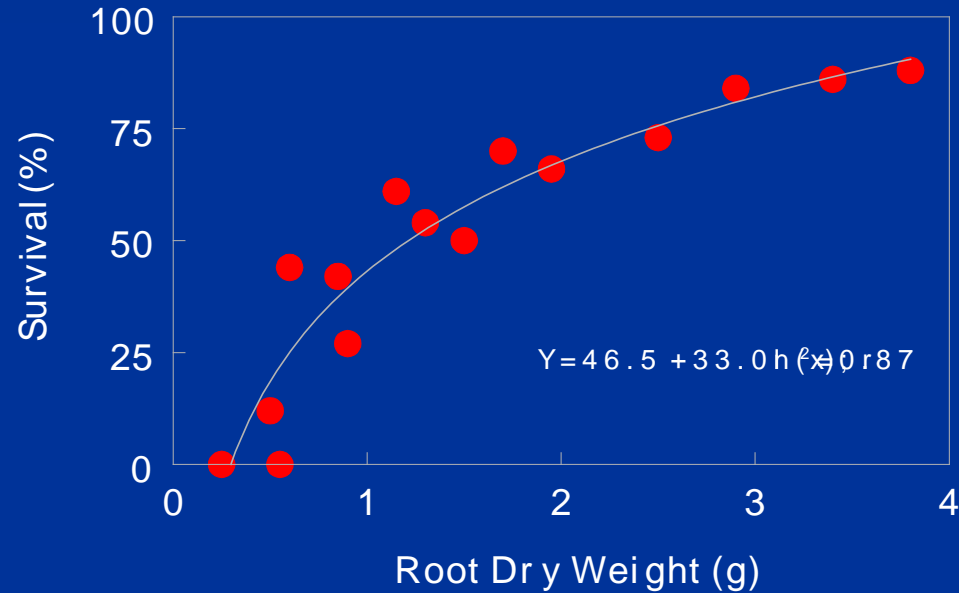


“The most important cause of death of transplanted seedlings is desiccation.”

Kozlowski and Davies (1975)

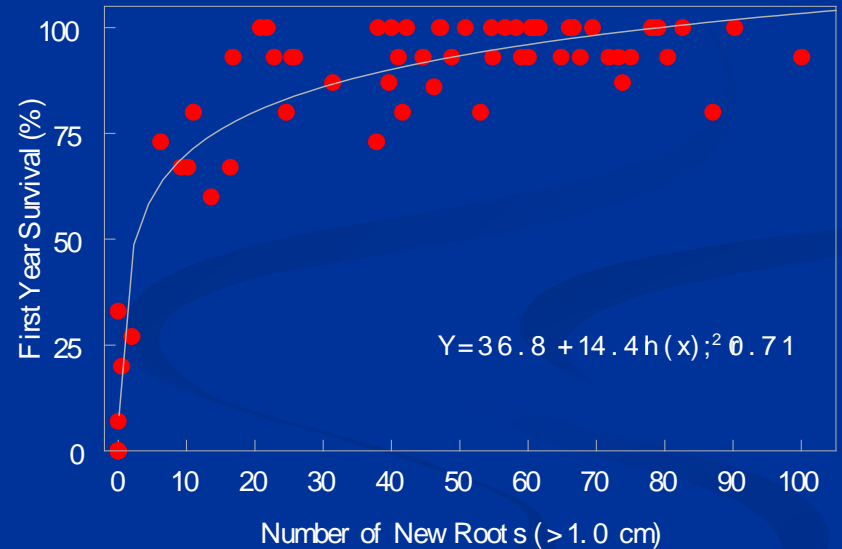
Roots & Seedling Survival

Initial Root System Size



Bake et al 1989

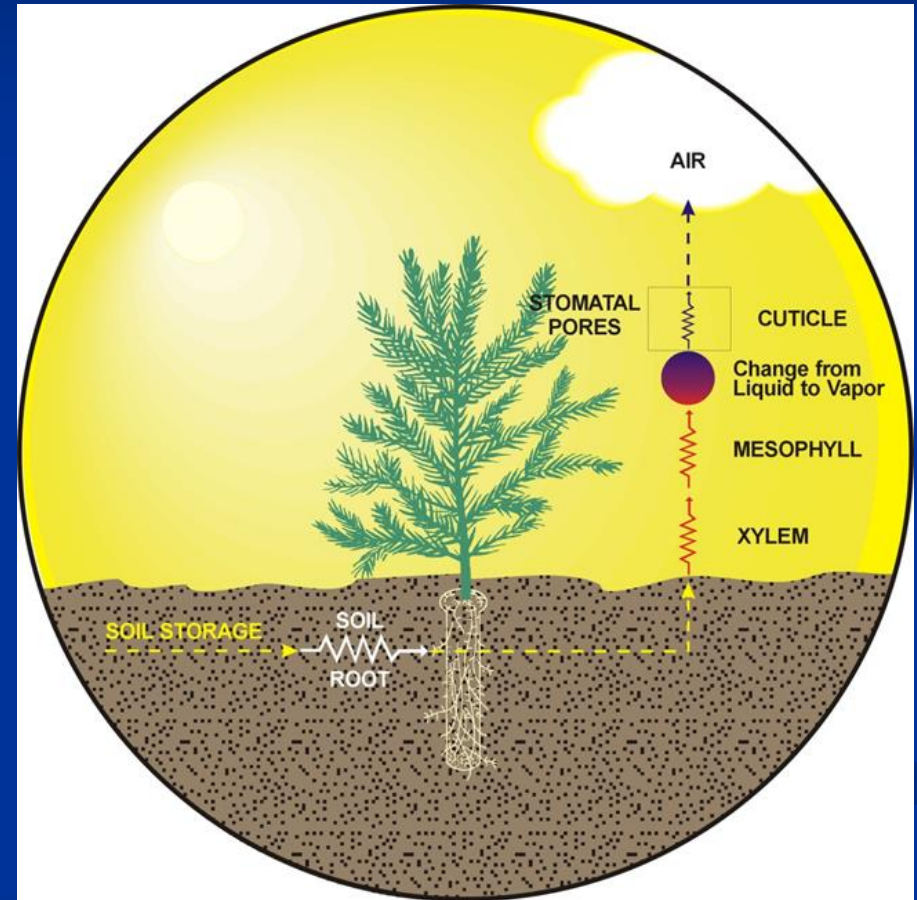
Root Growth Capacity



Simpson 1990

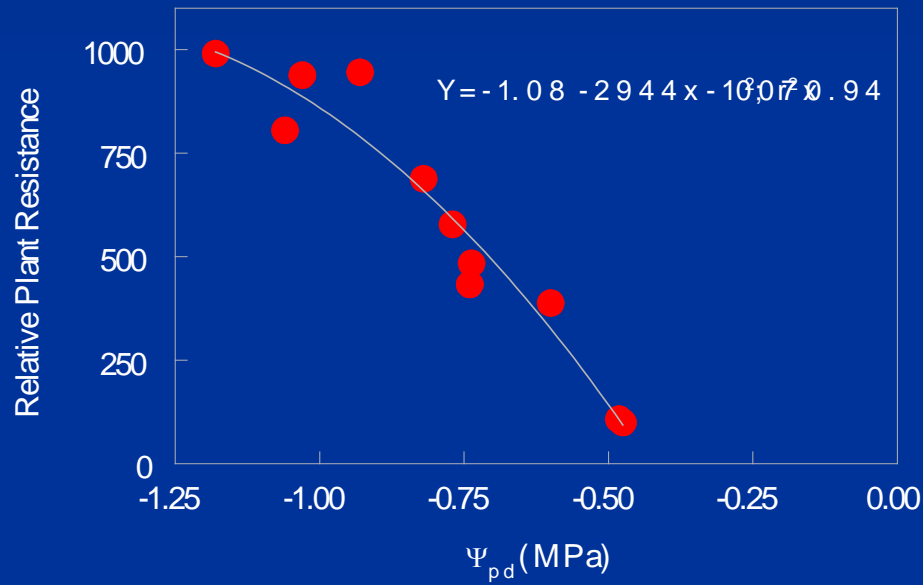
Water Movement & the SPAC

Water Flow = Difference
in Ψ / resistance to
water and vapor flow

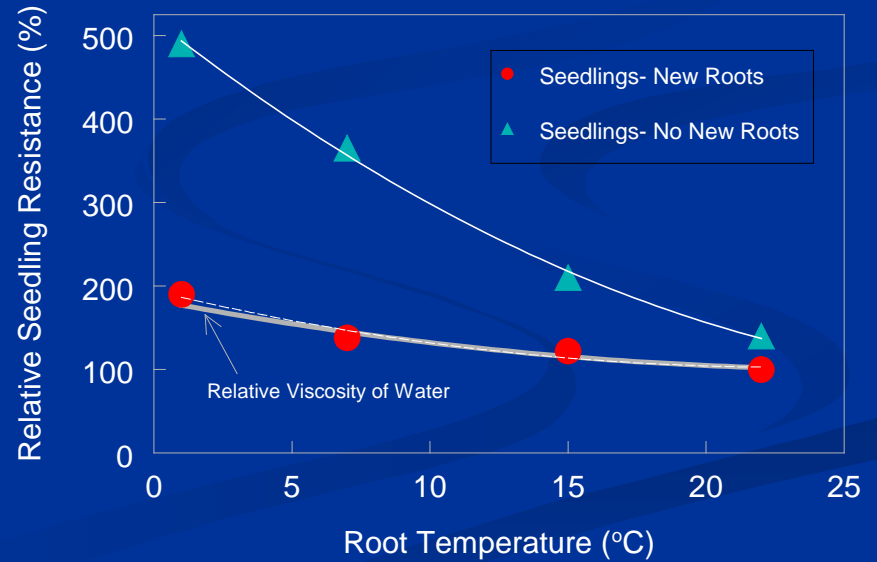


Soil Factors

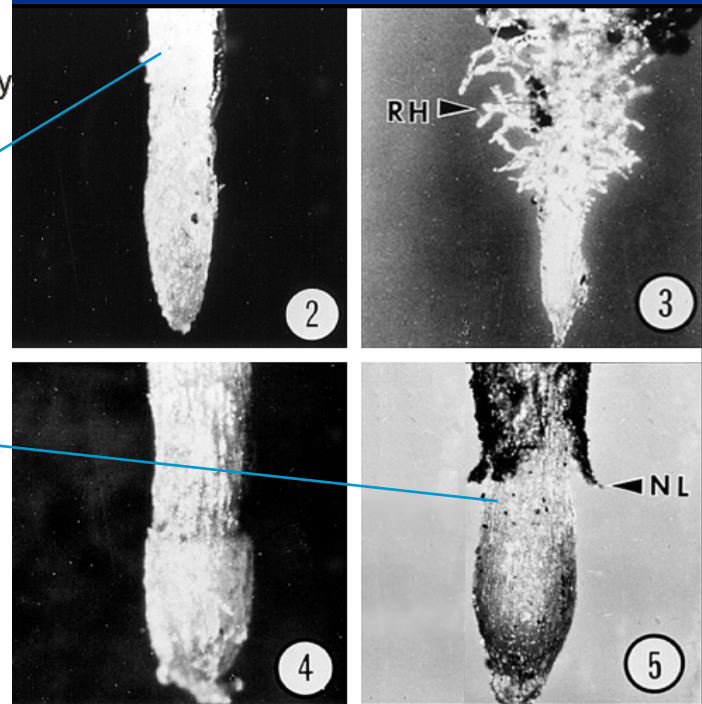
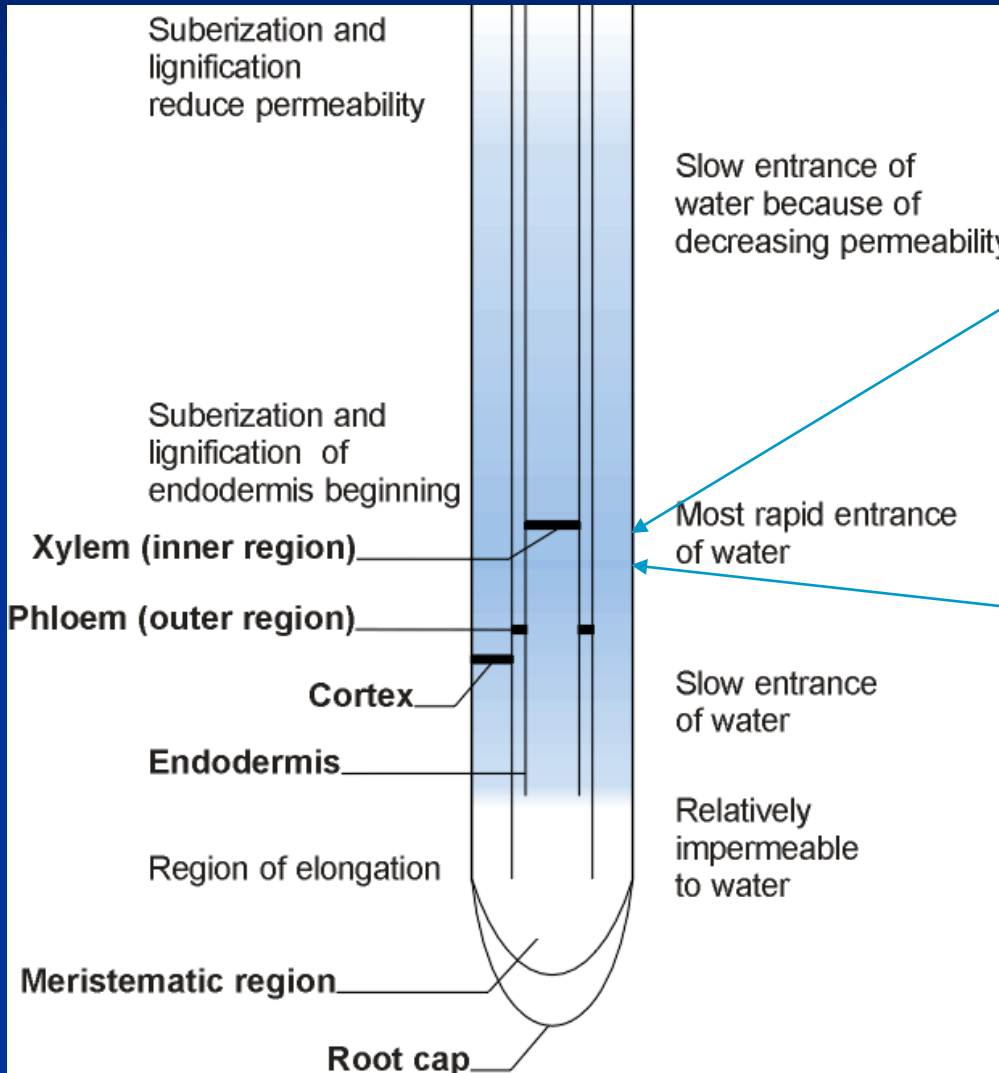
Water



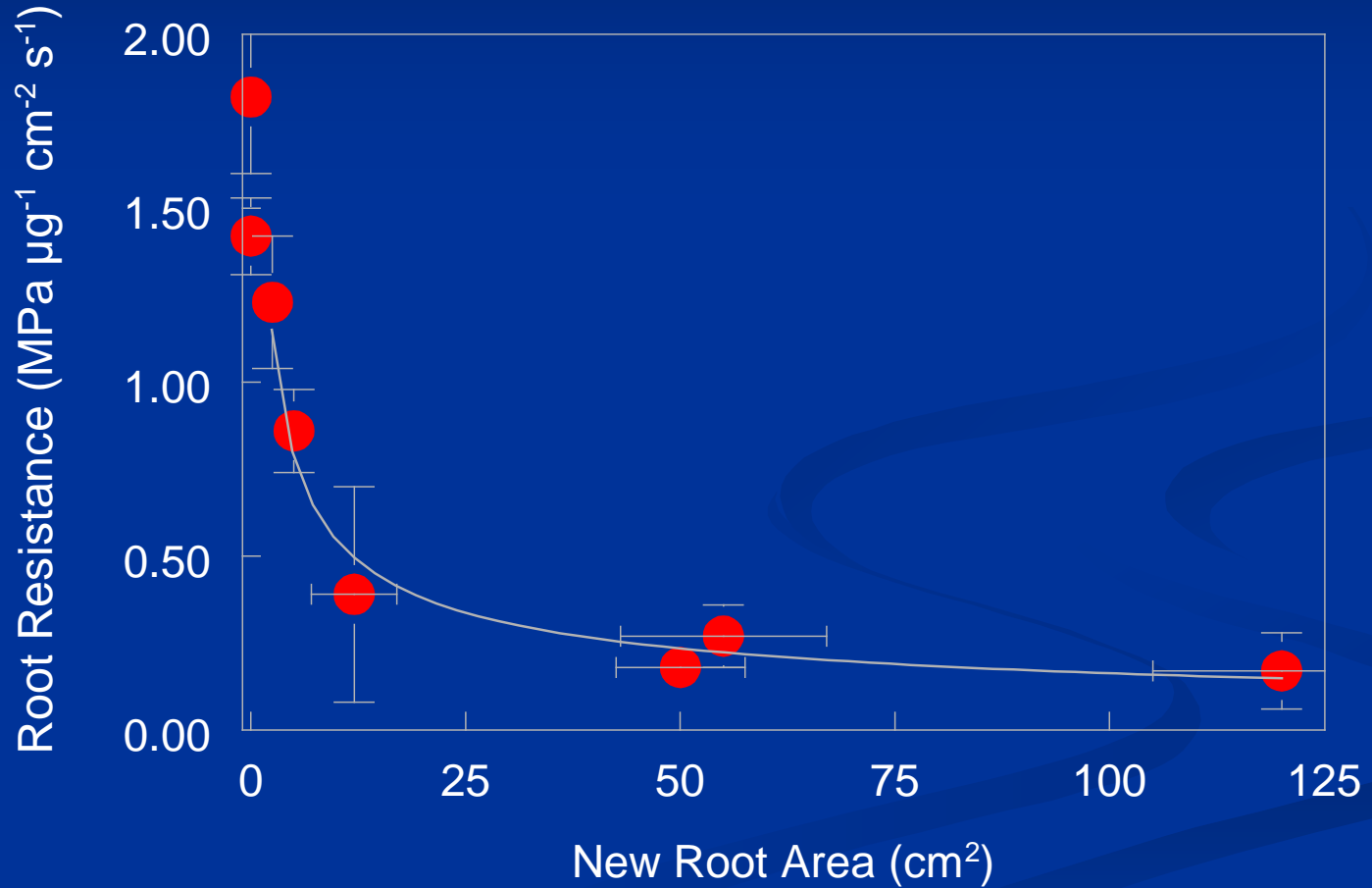
Temperature



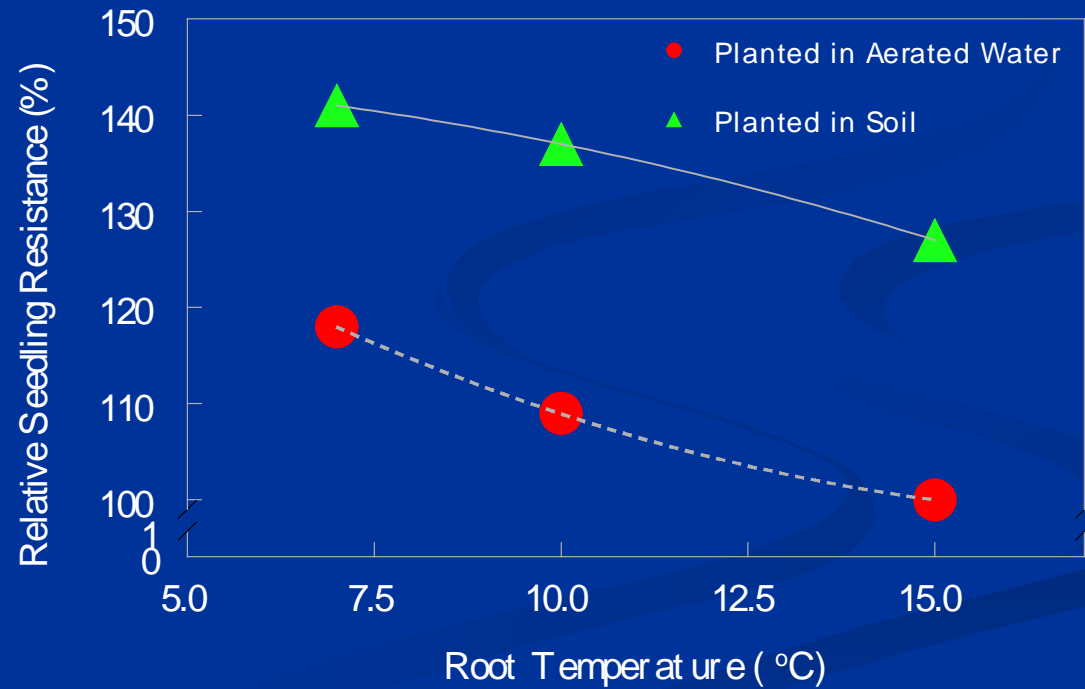
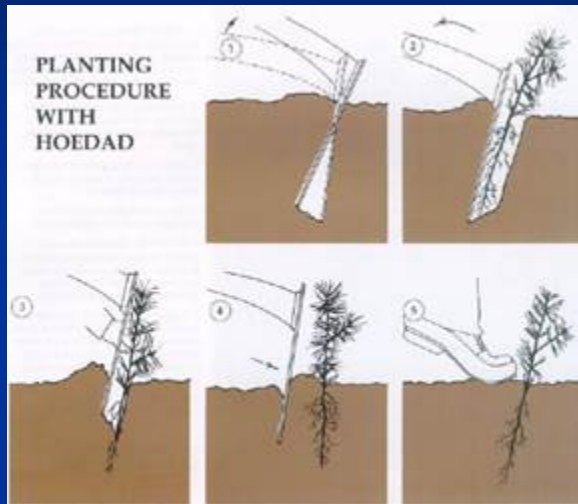
Location of Water Uptake



Root Permeability

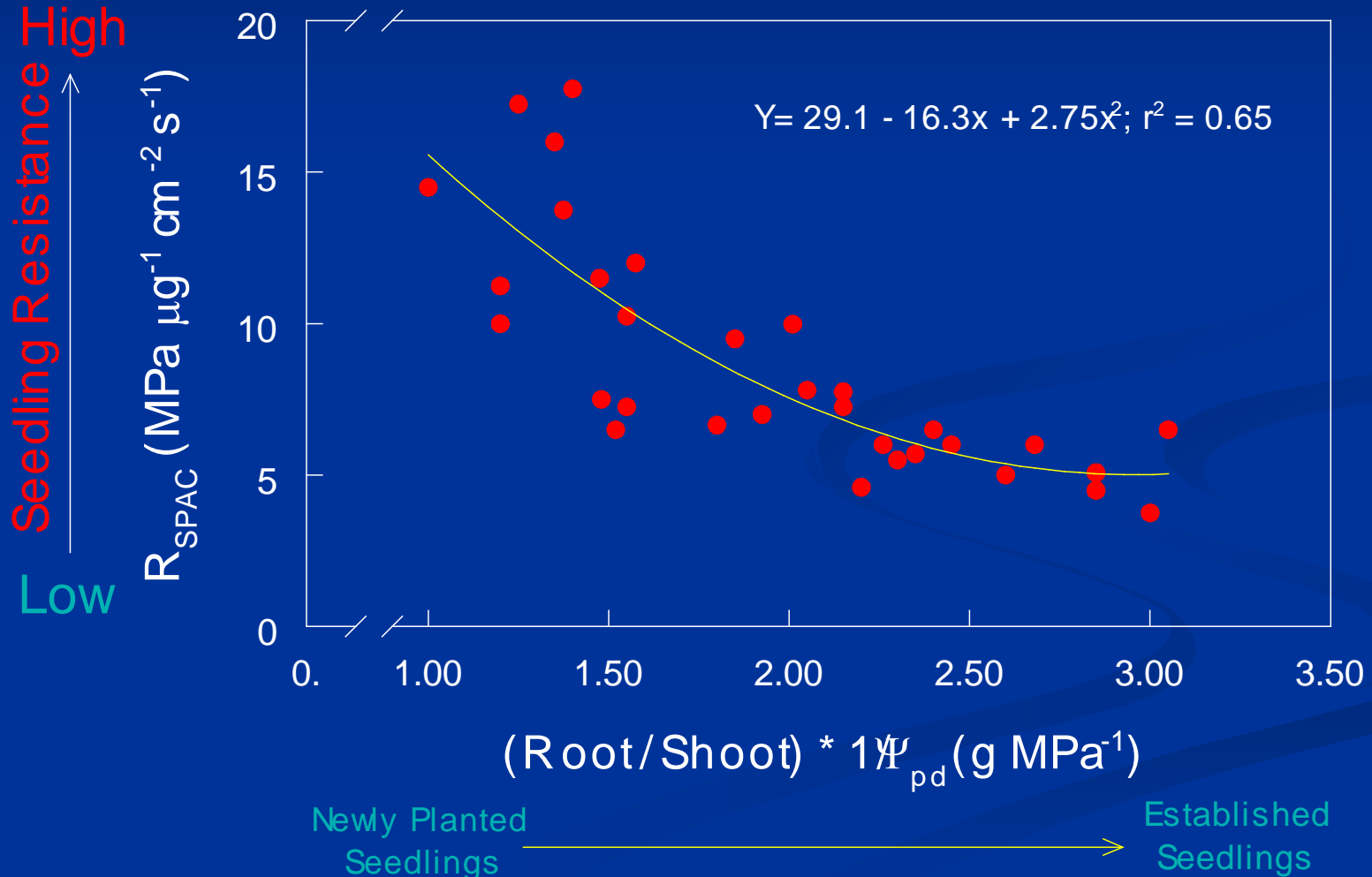


Root-Soil Contact

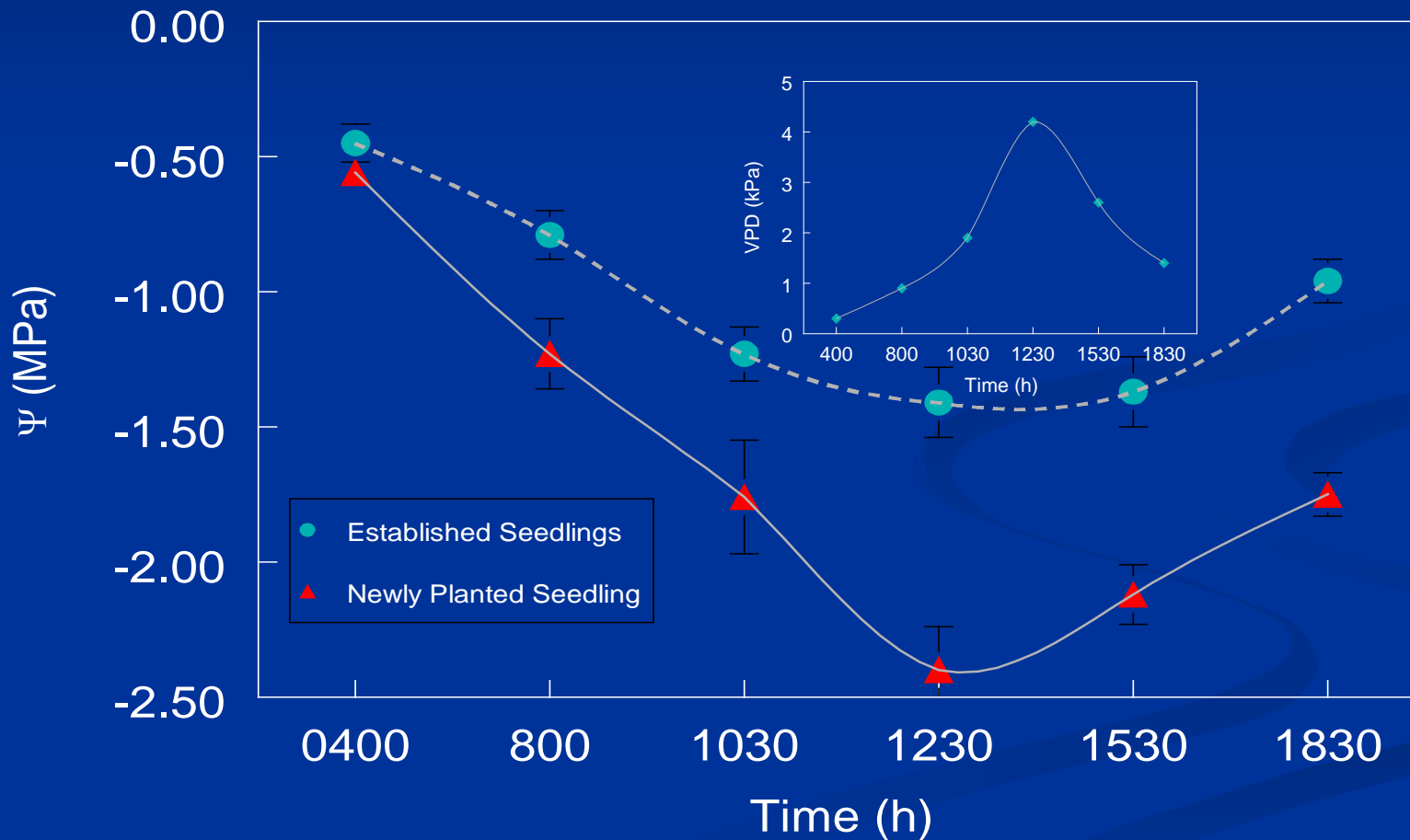


Root Confinement

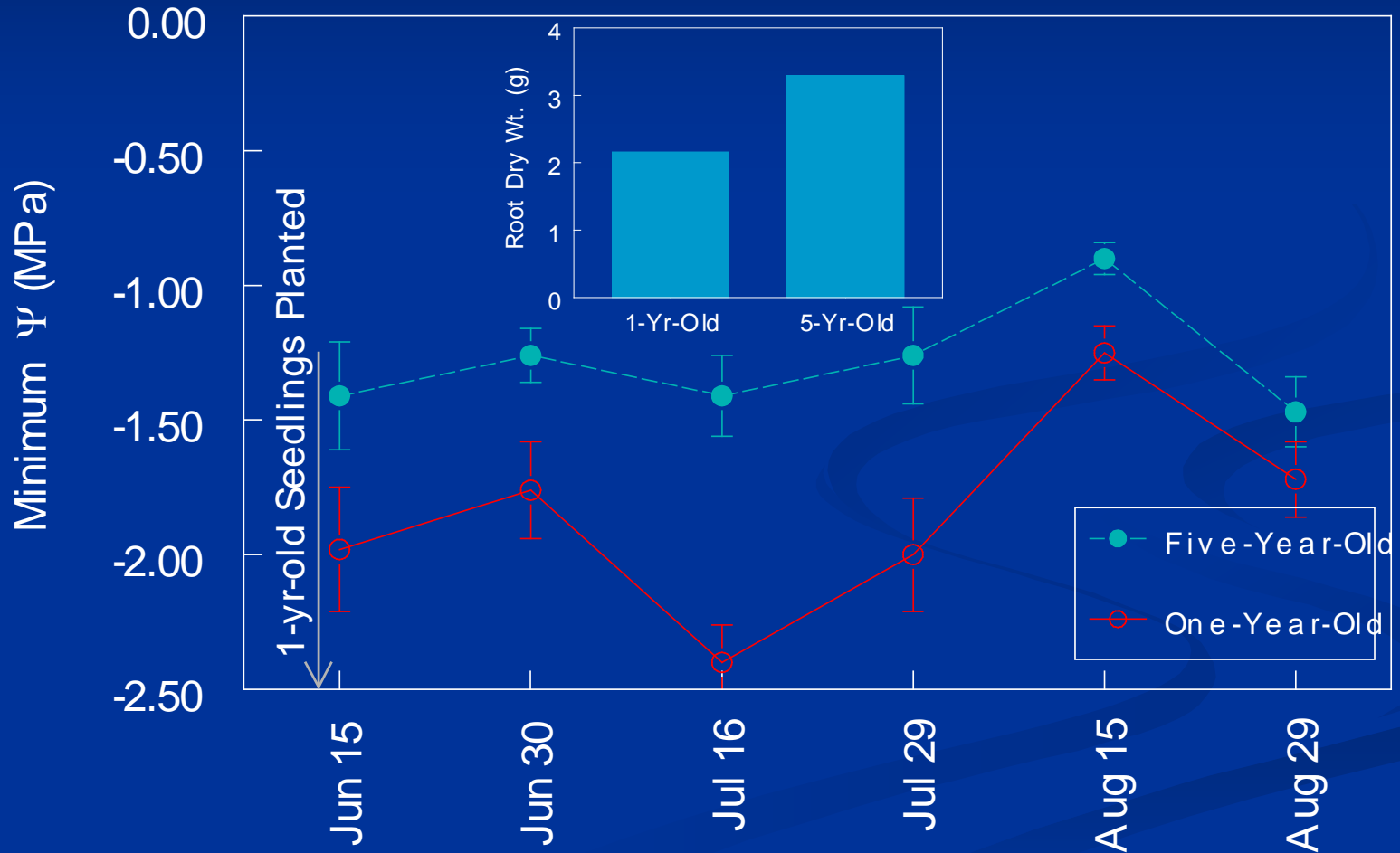
Limiting Water Movement into a Seedling



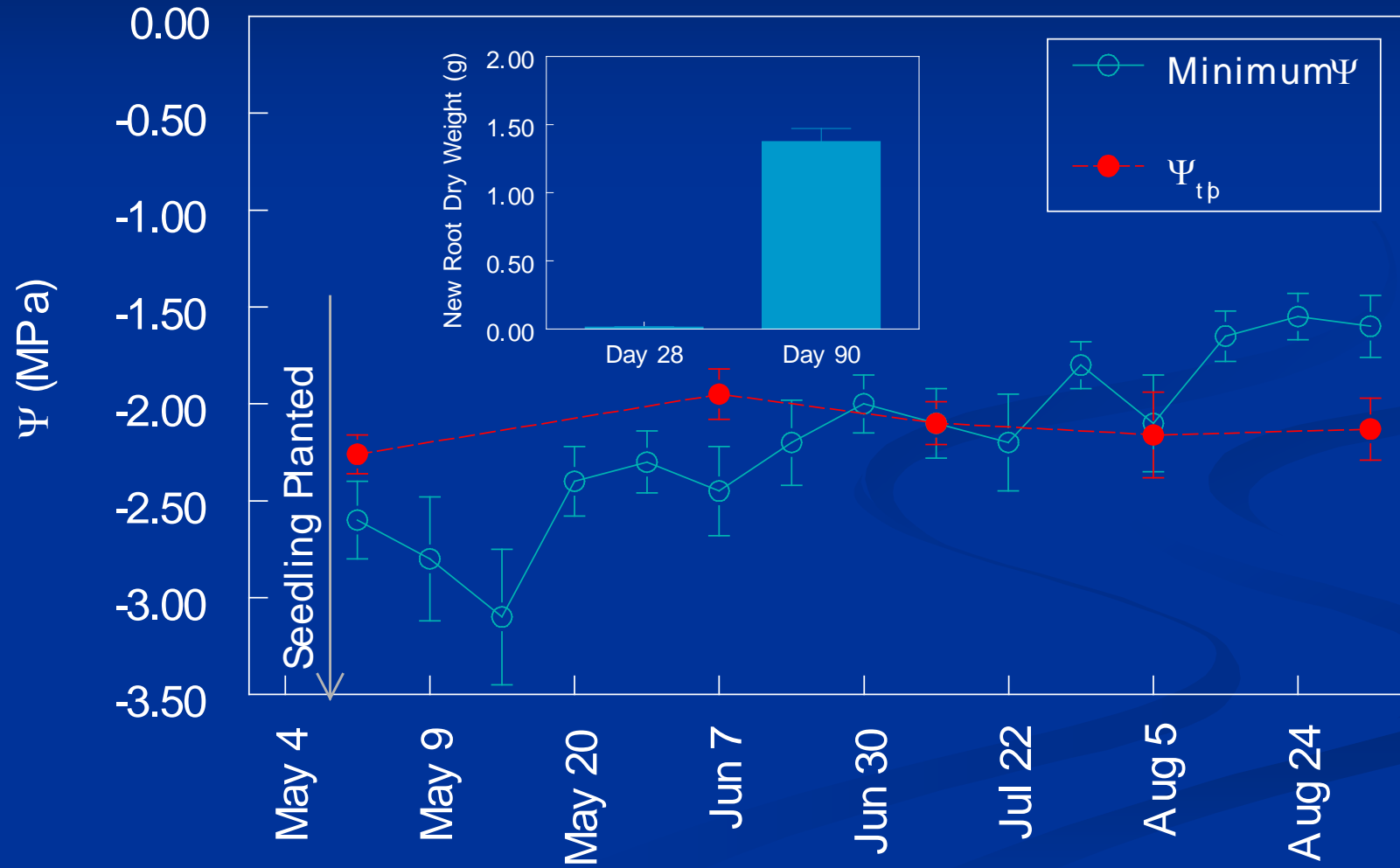
Diurnal Seedling Response



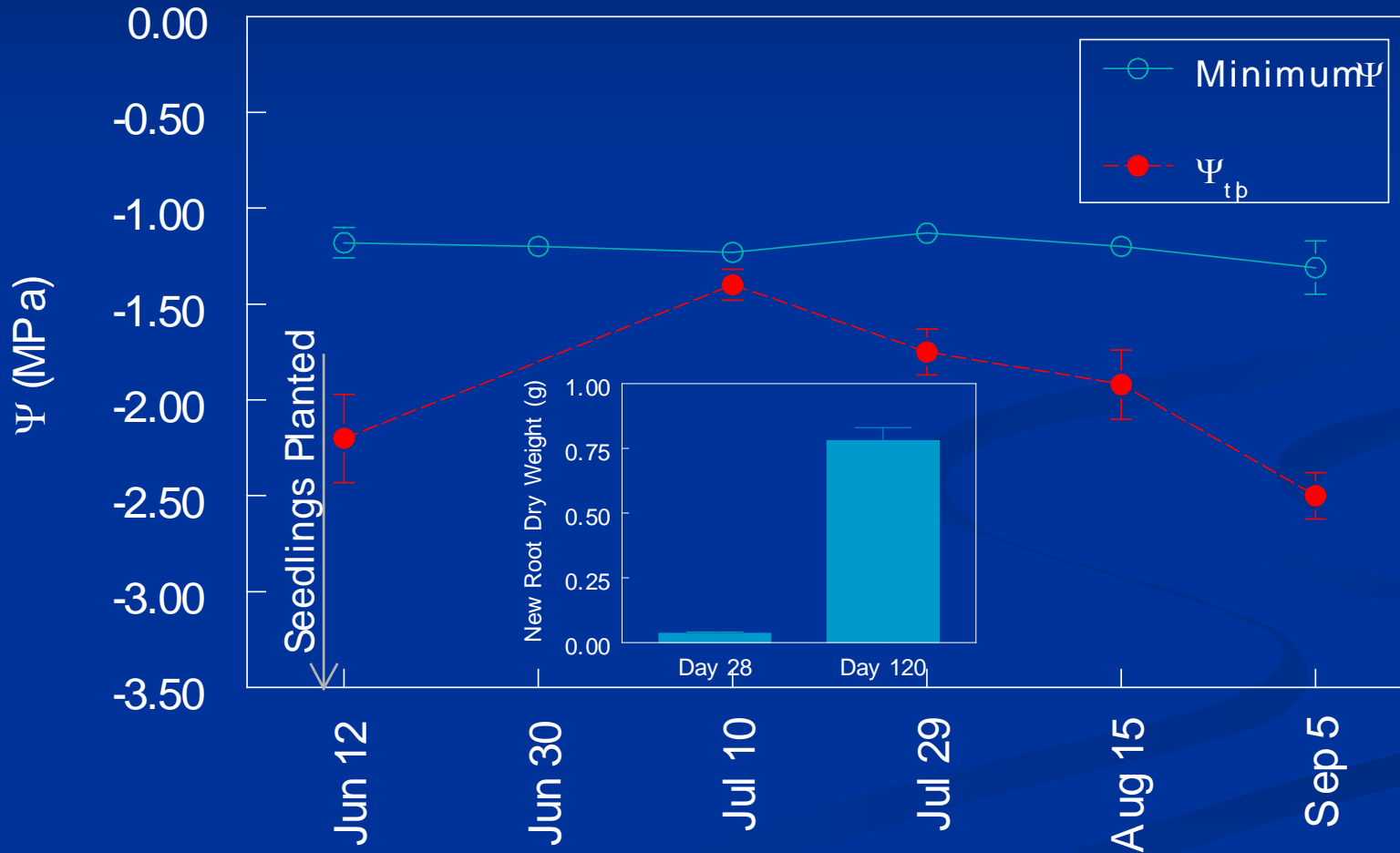
Moderate Seasonal Planting Stress



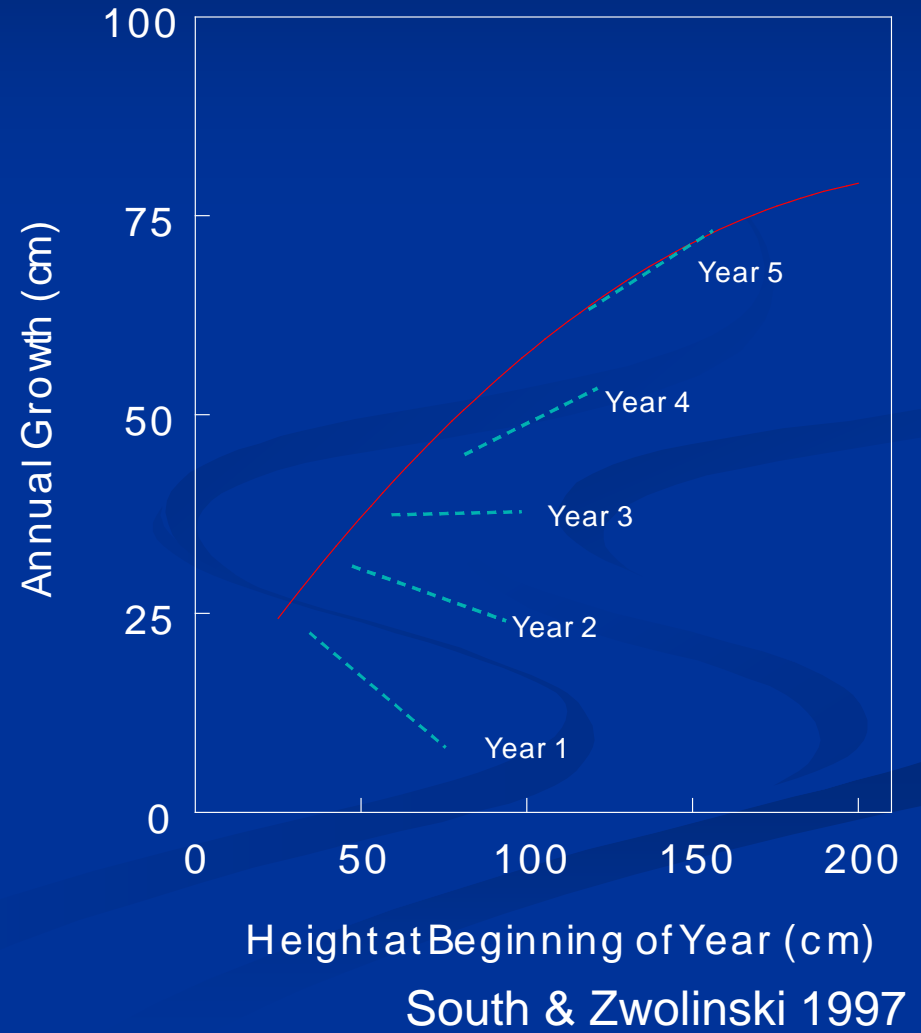
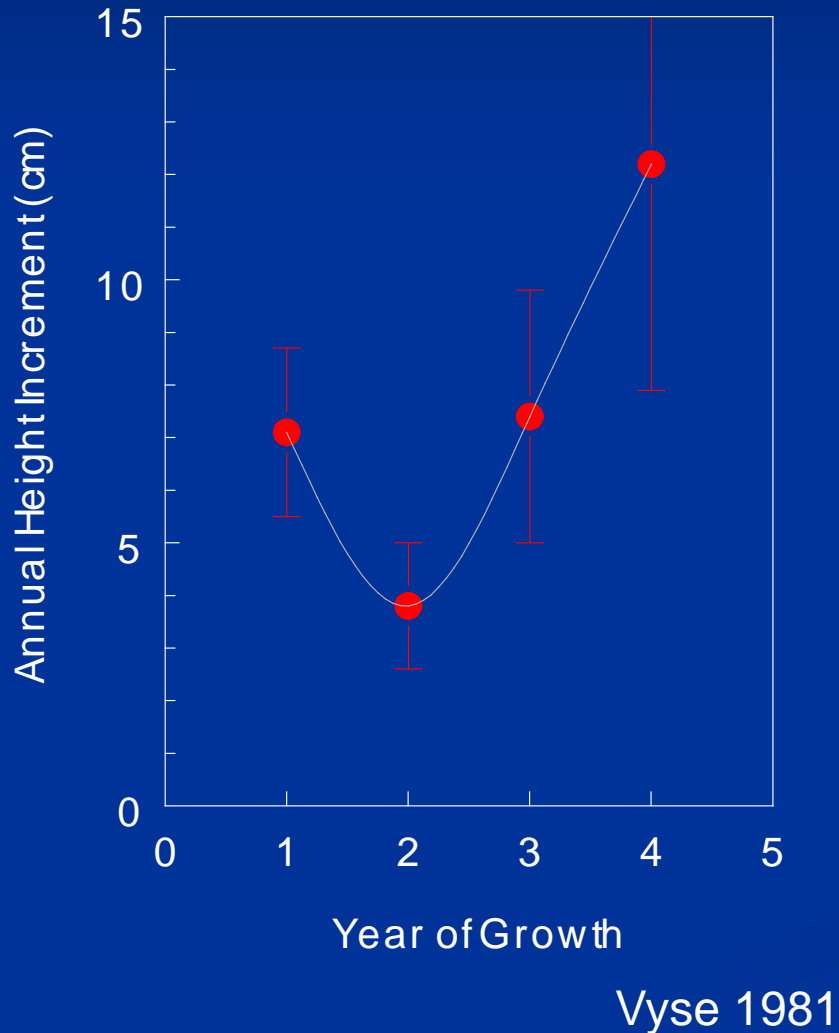
Severe Planting Stress



No Planting Stress



Planting Stress- Carry Over Effect

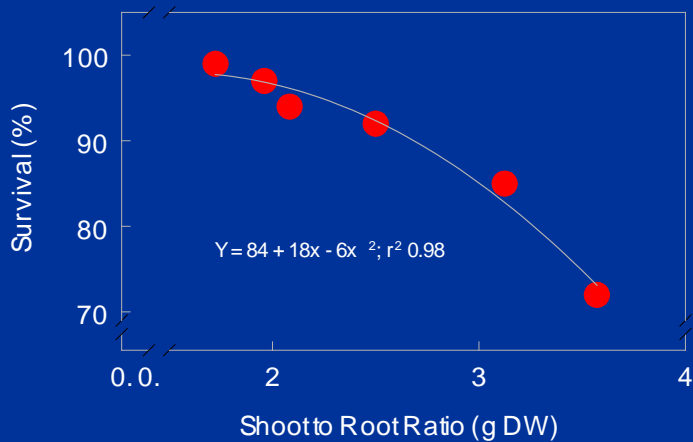
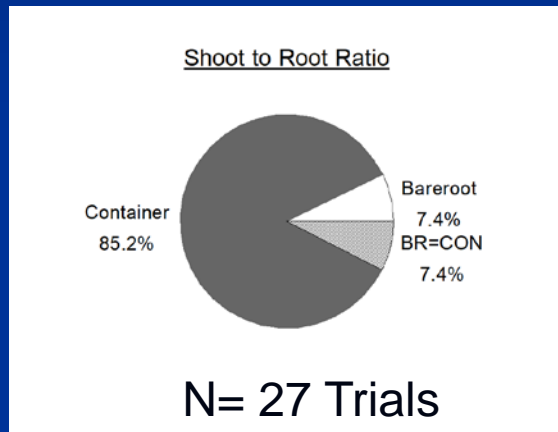


Planting Stress- Stocktype Effect

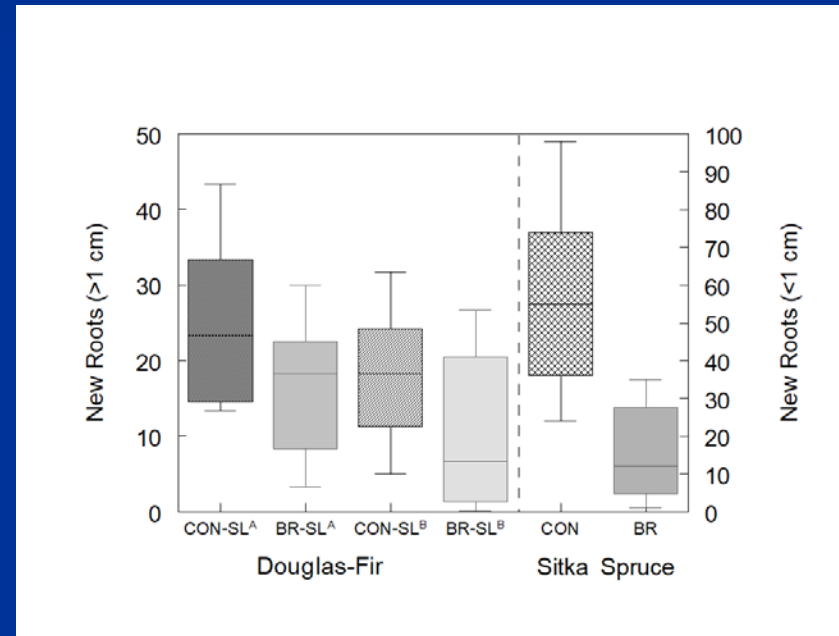
Container *Bareroot*



Planting Stress- Stocktype Effect Seedling Quality



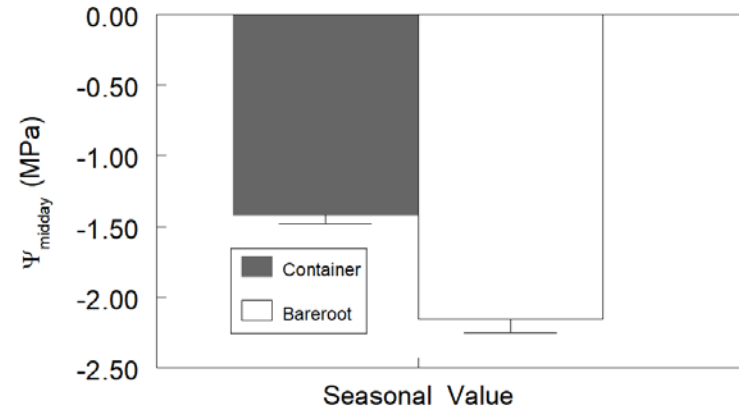
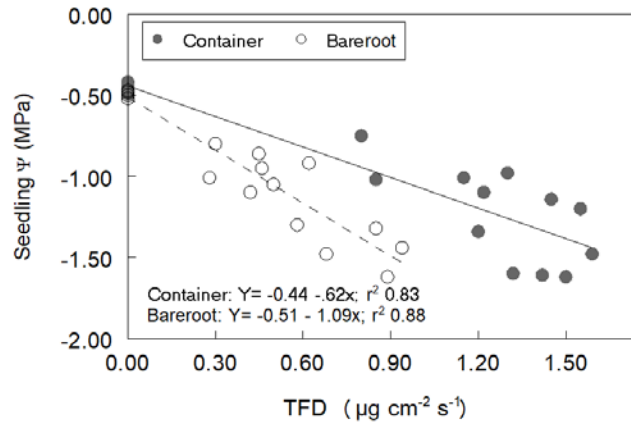
Mexal & Dougherty 1983



Binder et al. 1990

Planting Stress- Stocktype Effect

Field Site Water Relations

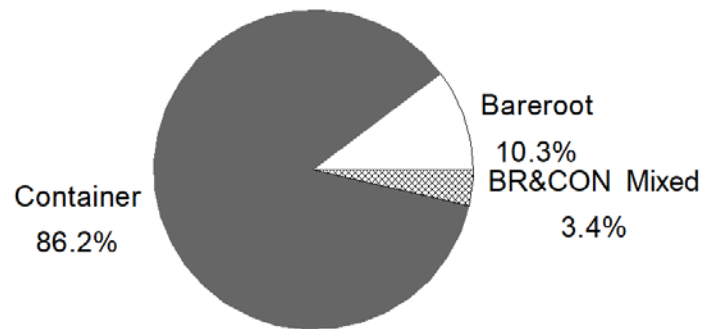


Dixon et al. 1983

Planting Stress- Stocktype Effect

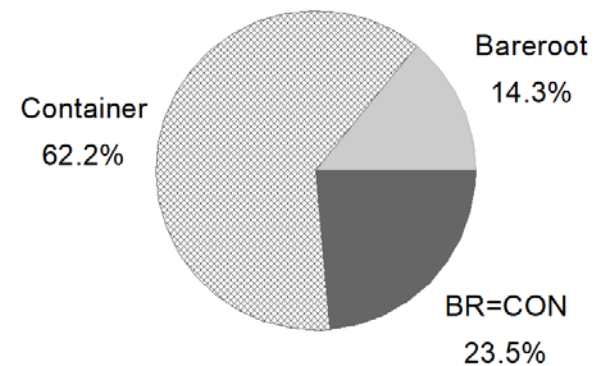
Field Performance

Root Growth



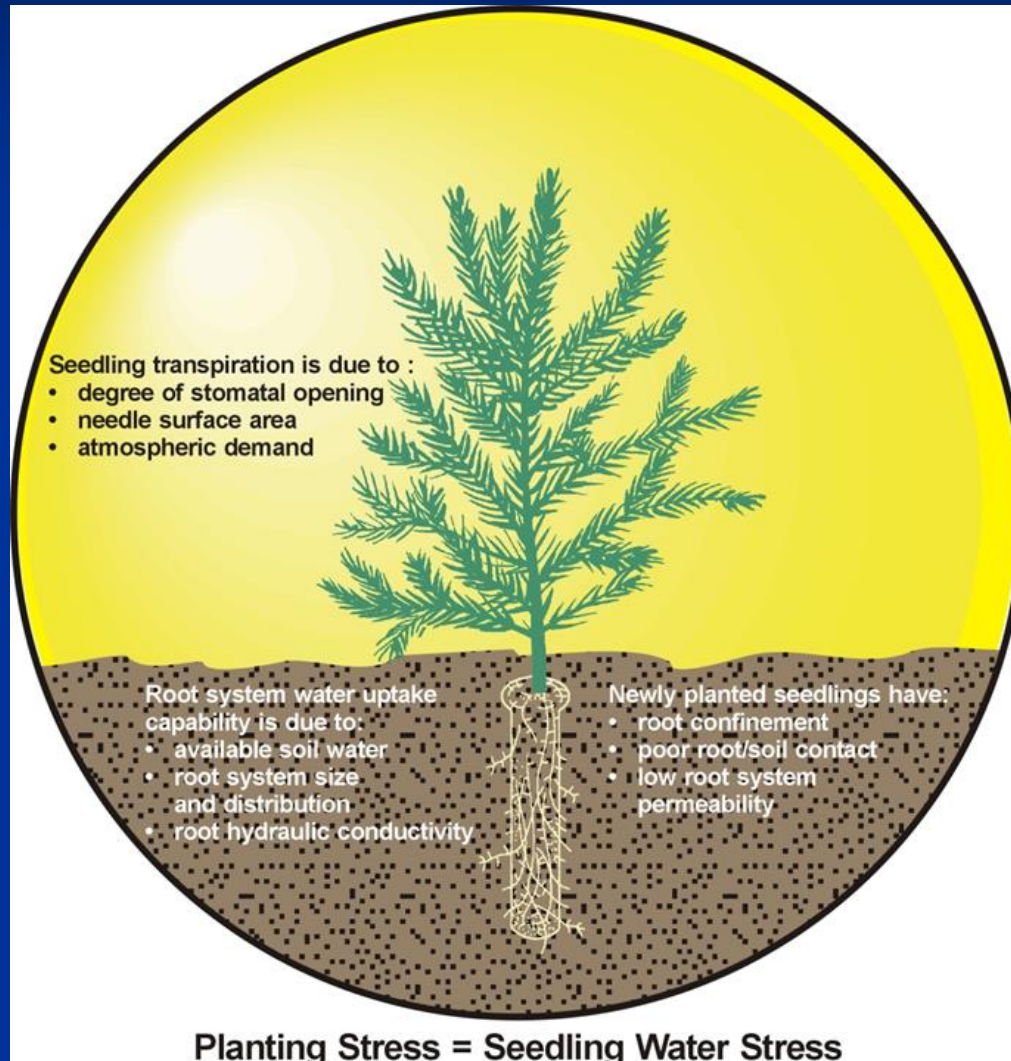
N= 29 Trials

Survival



N= 122 Trials

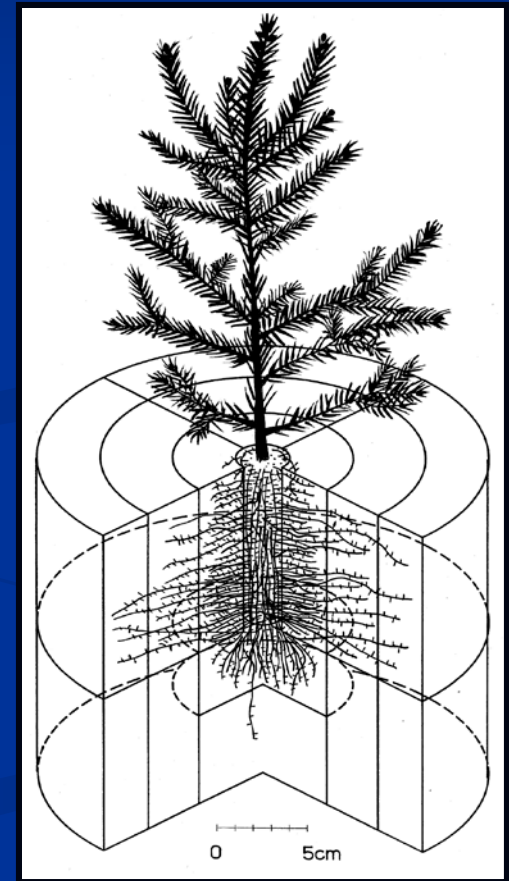
Planting Stress



Overcome Planting Stress by:

- Stocktype selection in relation to site conditions.
- Planting hardened seedlings with high root growth capability.
- Preparing favorable planting sites.
- Plant seedlings properly.
- Proper timing of planting (i.e., limit exposure to stressful conditions).

Root Growth = Coupling to Site



Closing Thoughts

