

# 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

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## Silvics

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



## Ecophysiology

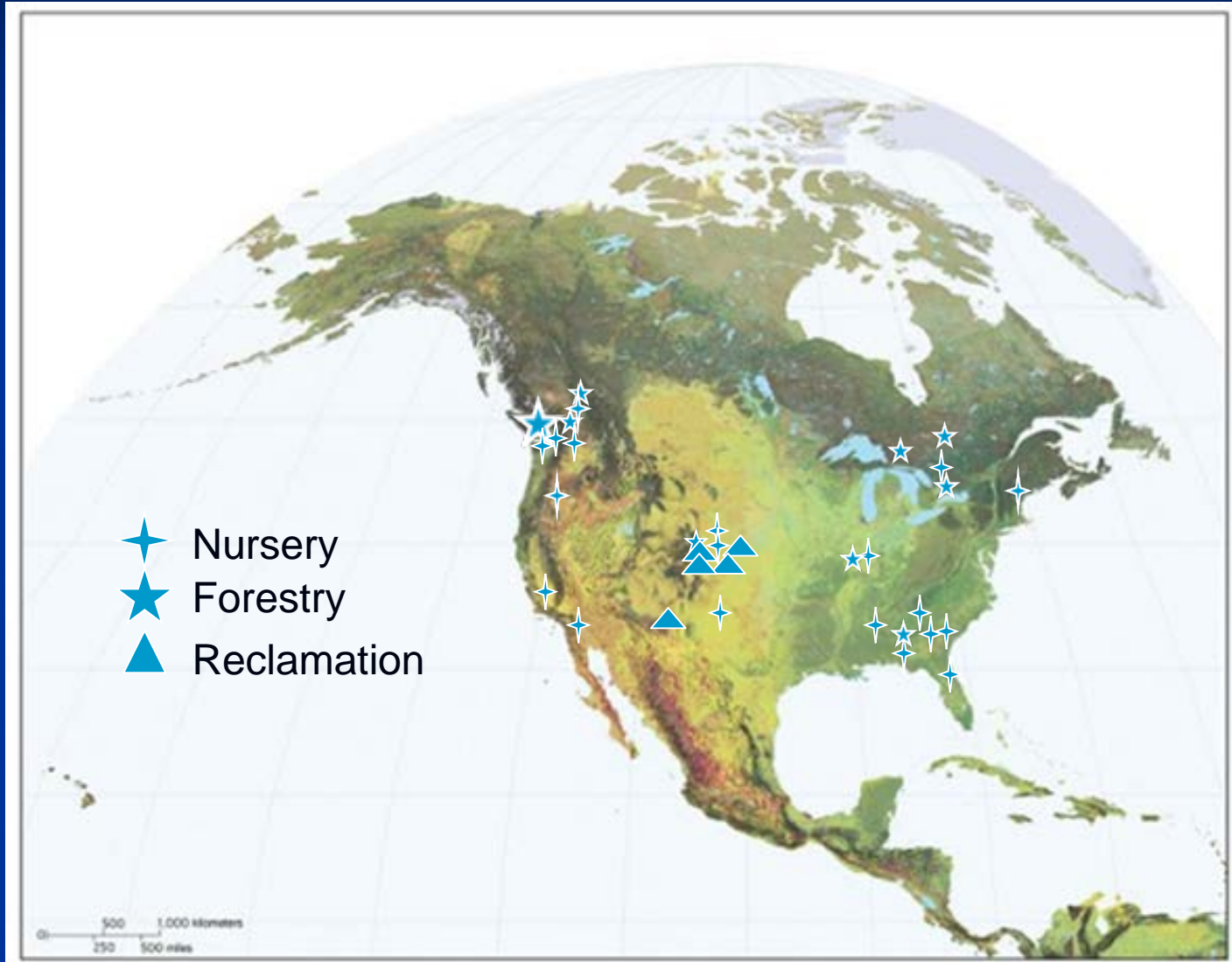
Physiological and morphological processes of plants in *response to the surrounding environment.*

# Ecophysiological Approach

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

# Programs across North America

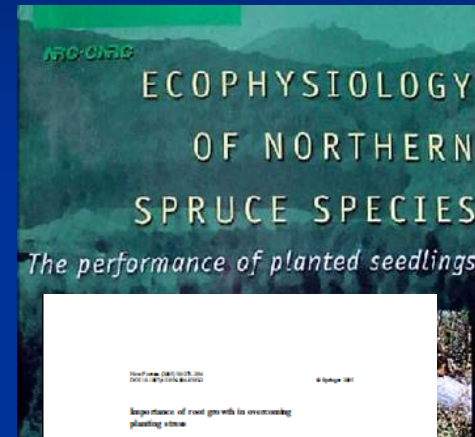


# Information Sources

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](https://www.researchgate.net/profile/Steve_Grossnickle)



**Importance of root growth in increasing planting success**

**Why seedling survives: influence of plant attributes**

**Why seedling grows: influence of plant attributes**

**Restoration Silviculture: An ecophysiological perspective - Lessons learned across 40 years**

**Steve Grossnickle**

**Abstract**

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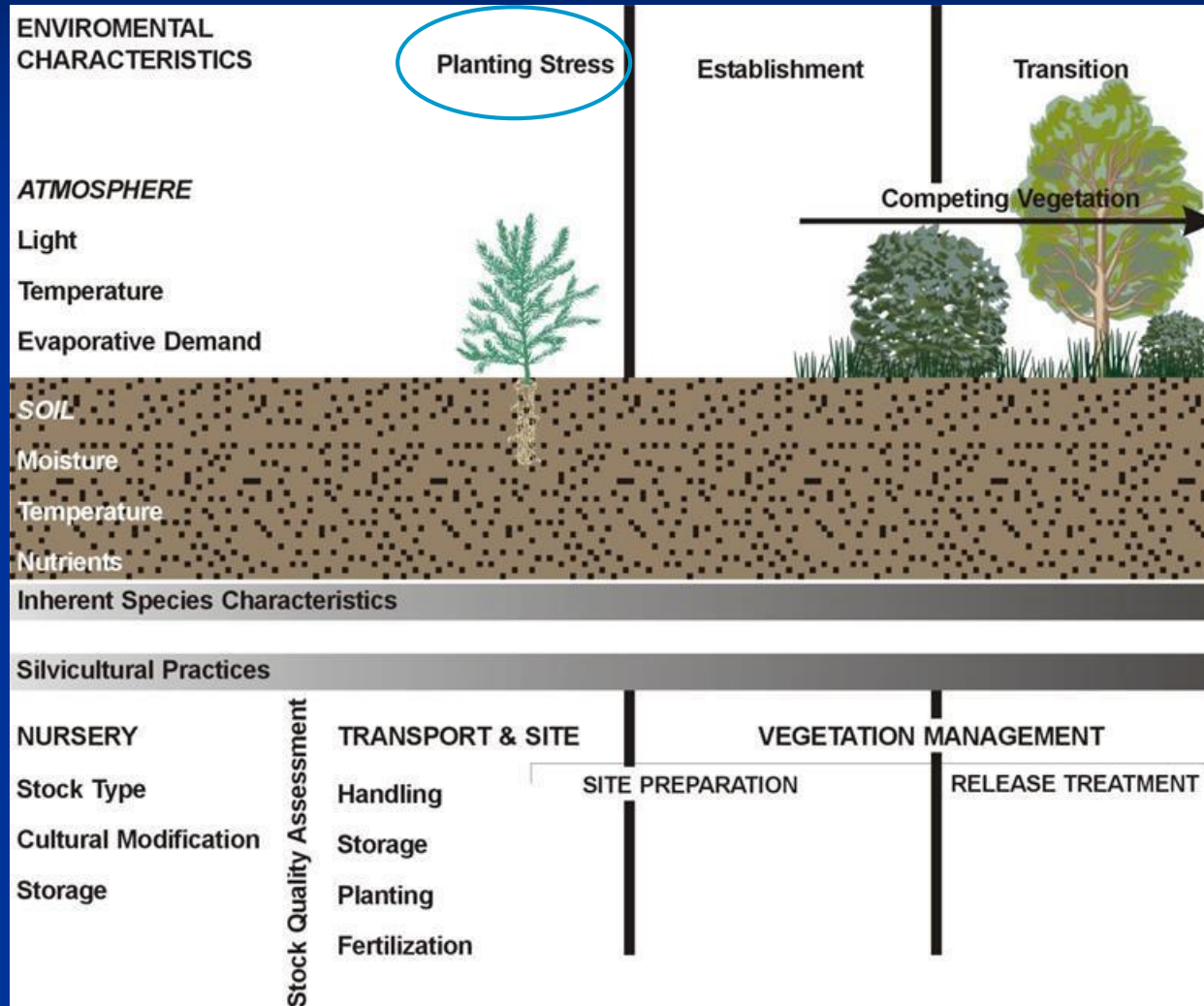
**Steve Grossnickle**

**Abstract**

**Keywords**



# Forest Regeneration Process



# Seedlings can grow anywhere!

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# Seedlings don't always grow where we plant them!

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*Seedling mortality primarily occurs in the initial years after planting and is due to planting stress.*  
(Grossnickle 2005)



# Planting Stress

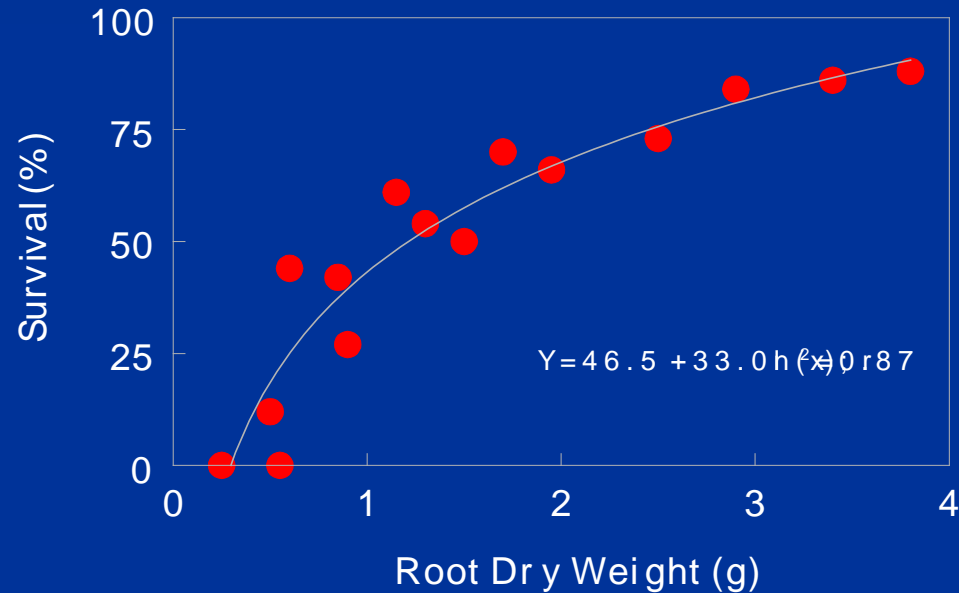
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*“The most important cause of death of transplanted seedlings is desiccation.”*

**(Kozlowski and Davies 1975)**

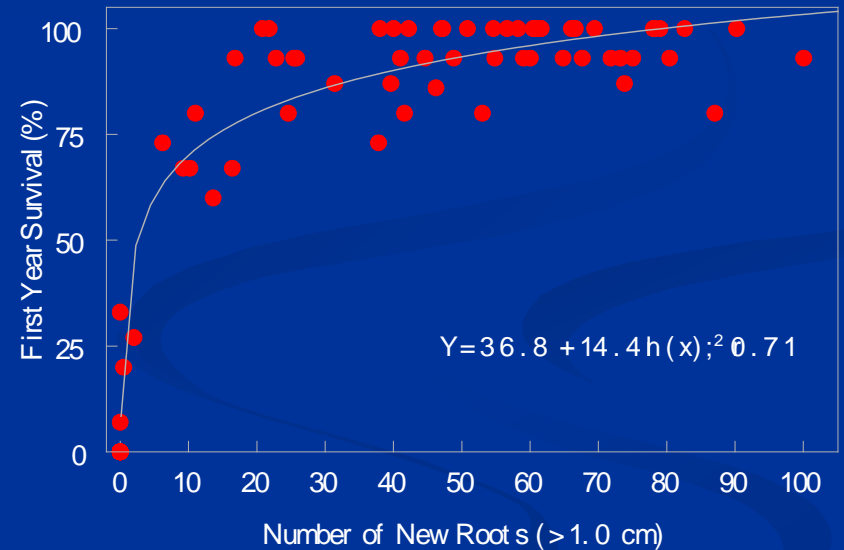
# Roots & Seedling Survival

## Initial Root System Size



Bake et al 1989

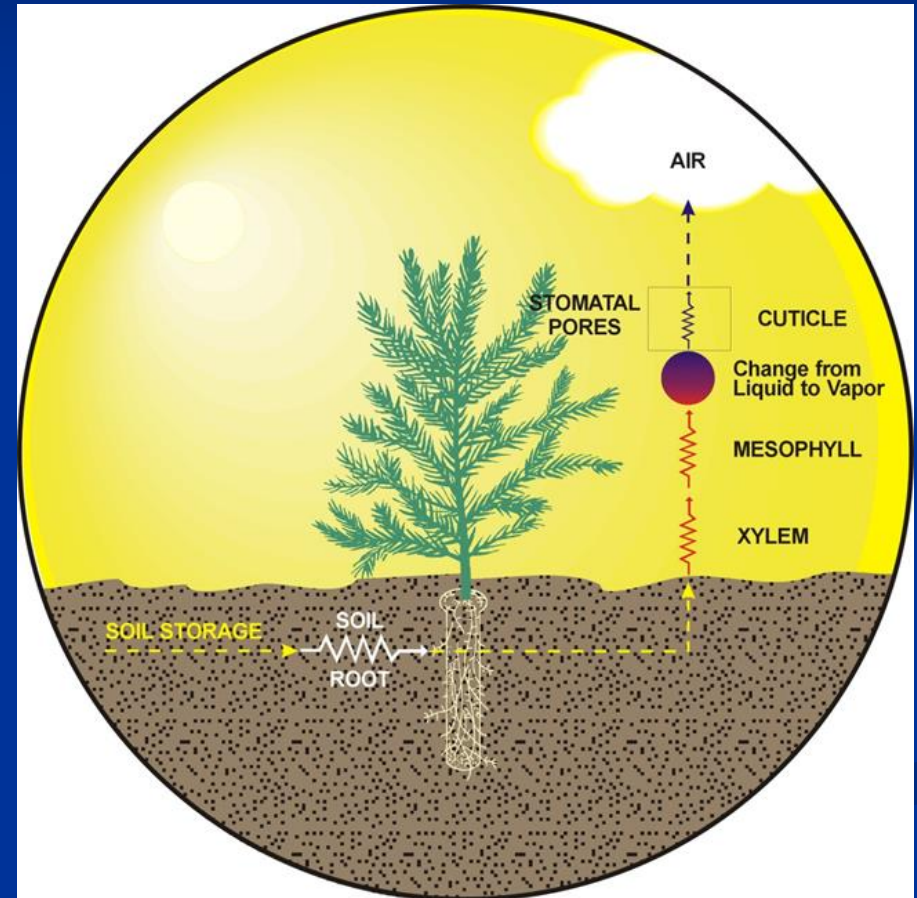
## Root Growth Capacity



Simpson 1990

# Water Movement & the SPAC

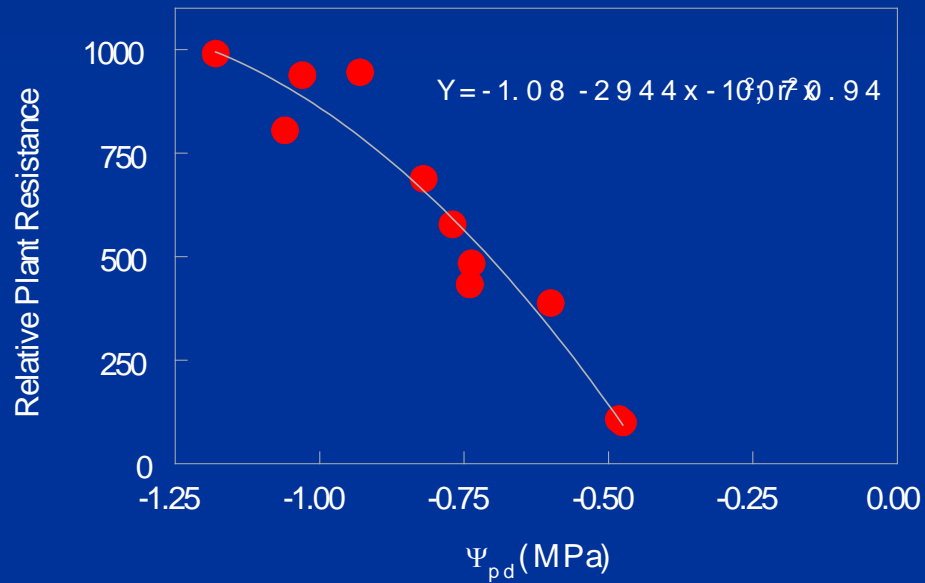
Water Flow =  
Difference in  $\Psi$  /  
resistance to water  
& vapor flow



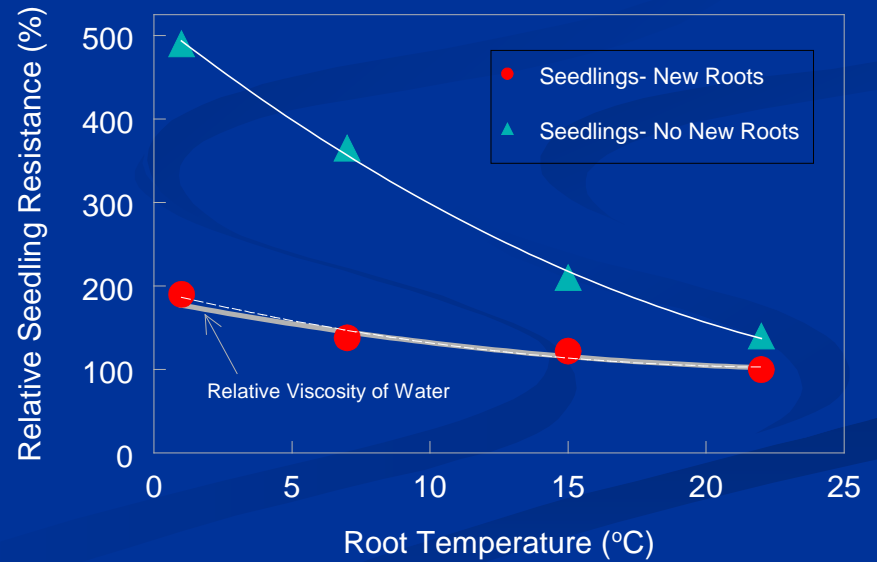


# Soil Factors

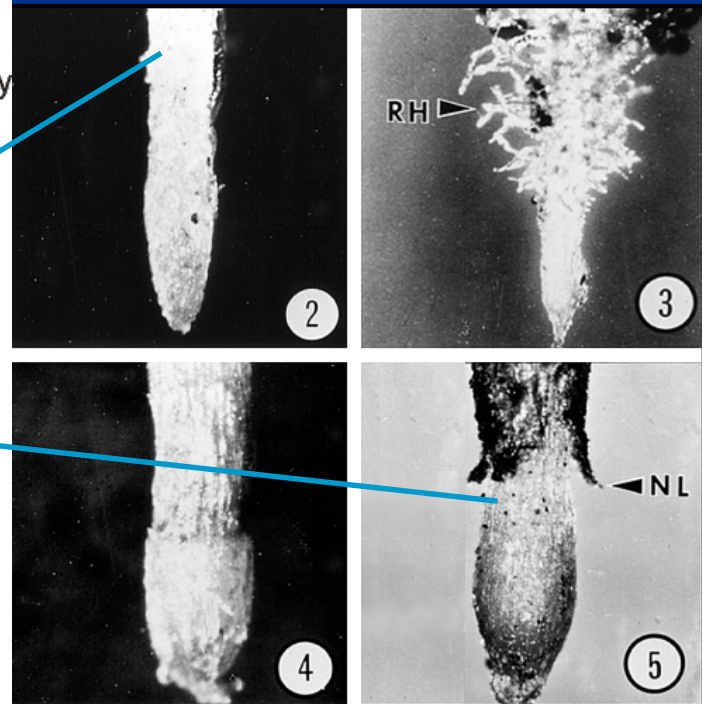
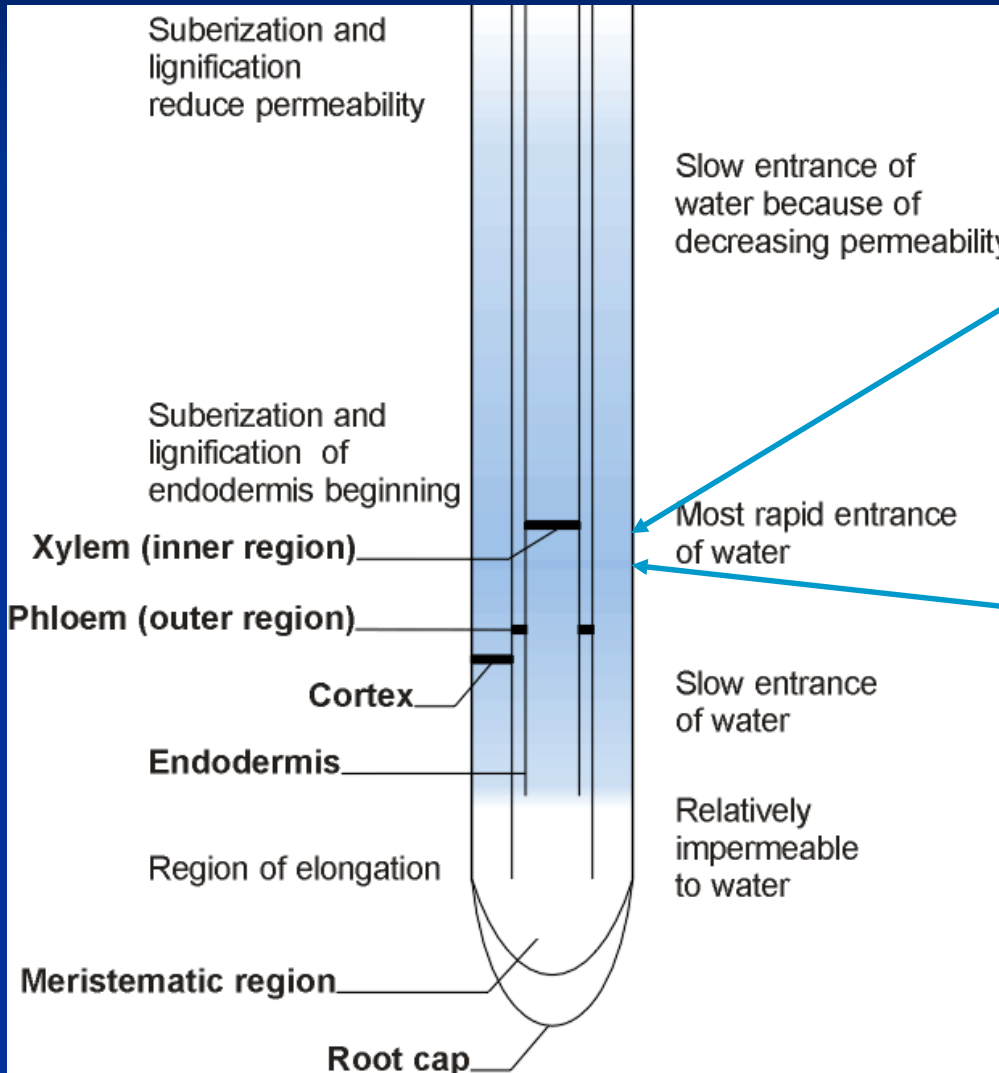
## Water



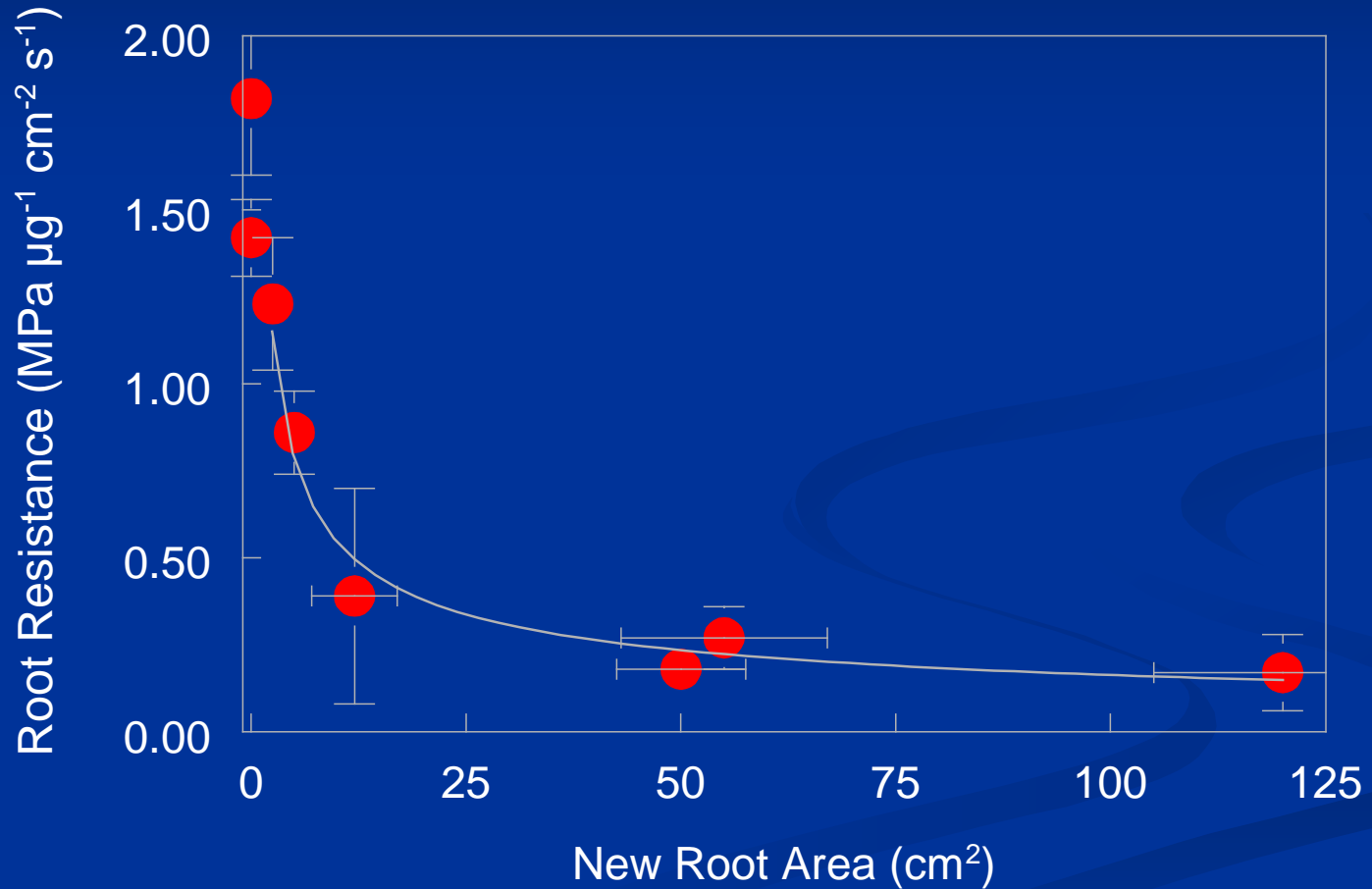
## Temperature



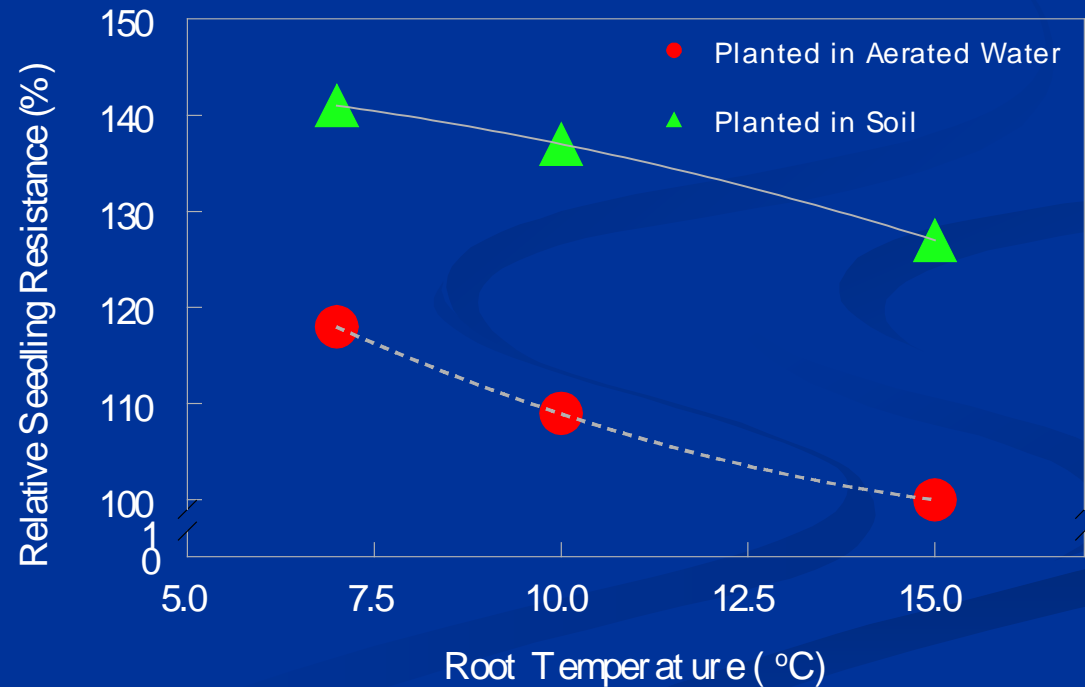
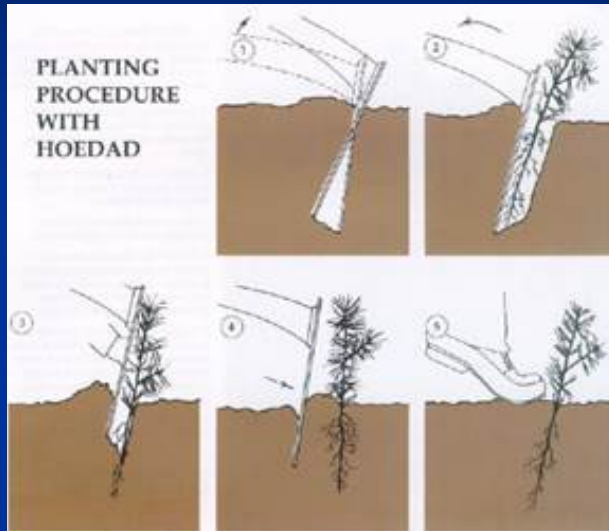
# Location of Water Uptake



# Root Permeability

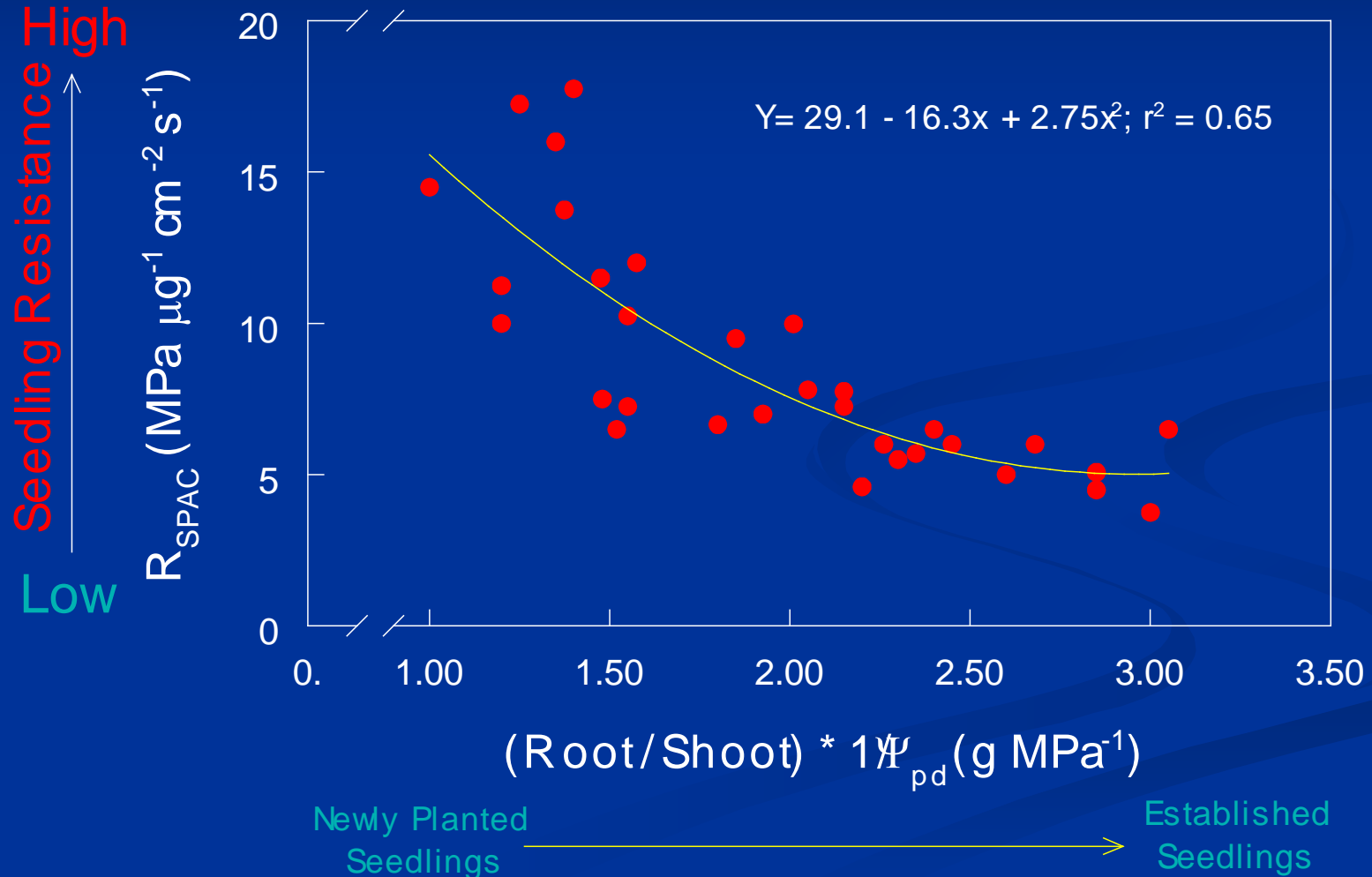


# Root-Soil Contact

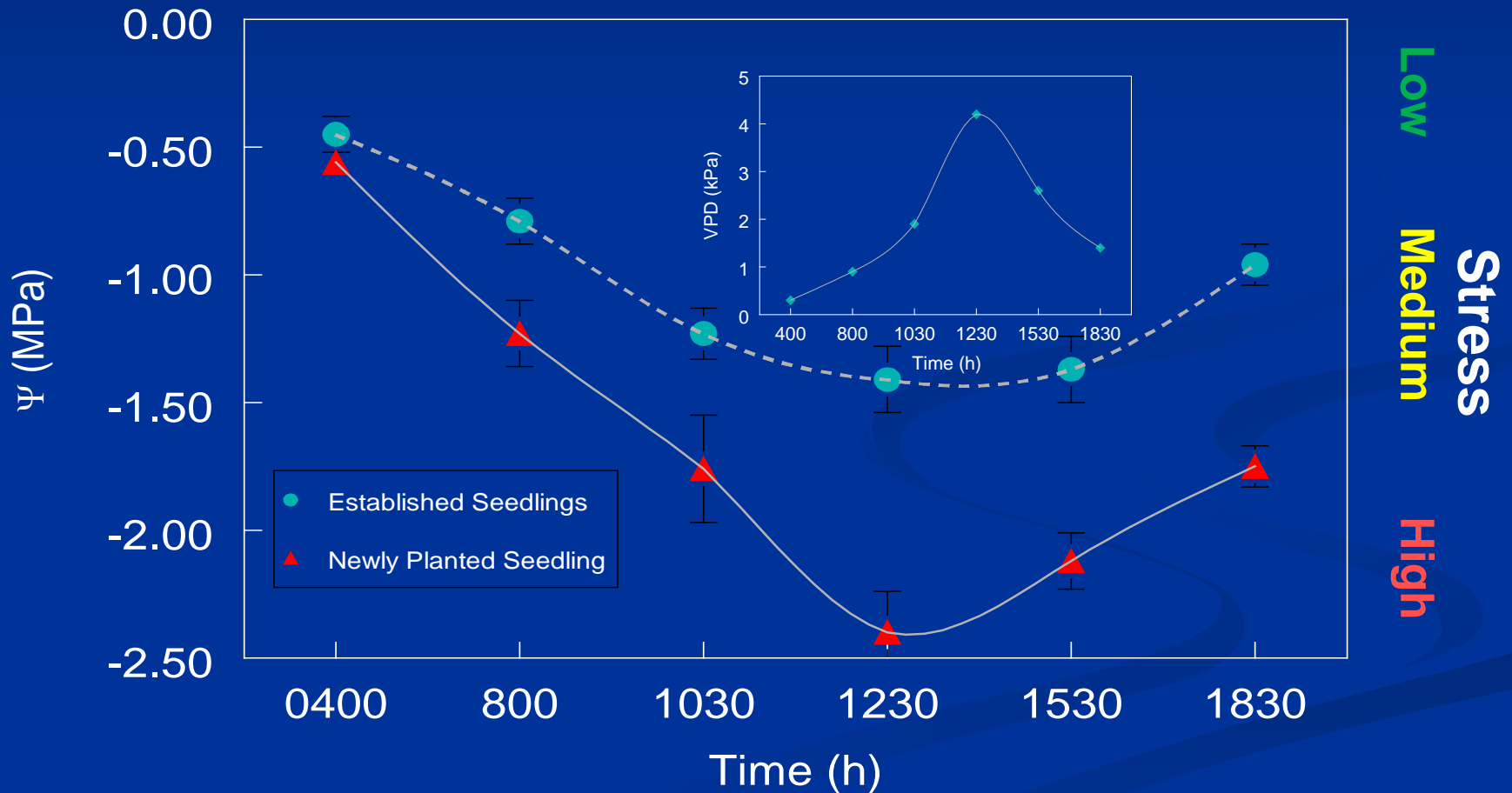




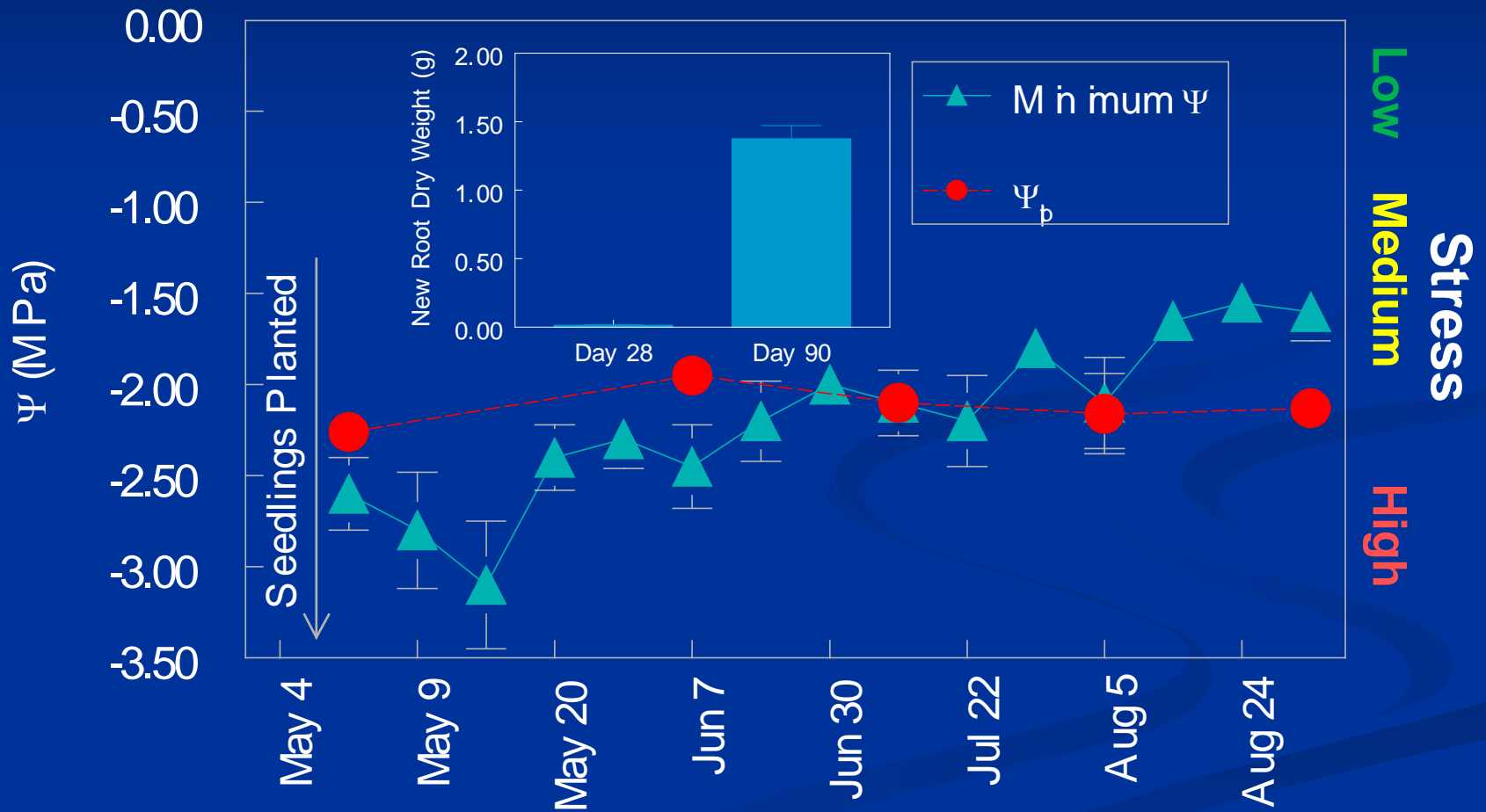
# Root Confinement



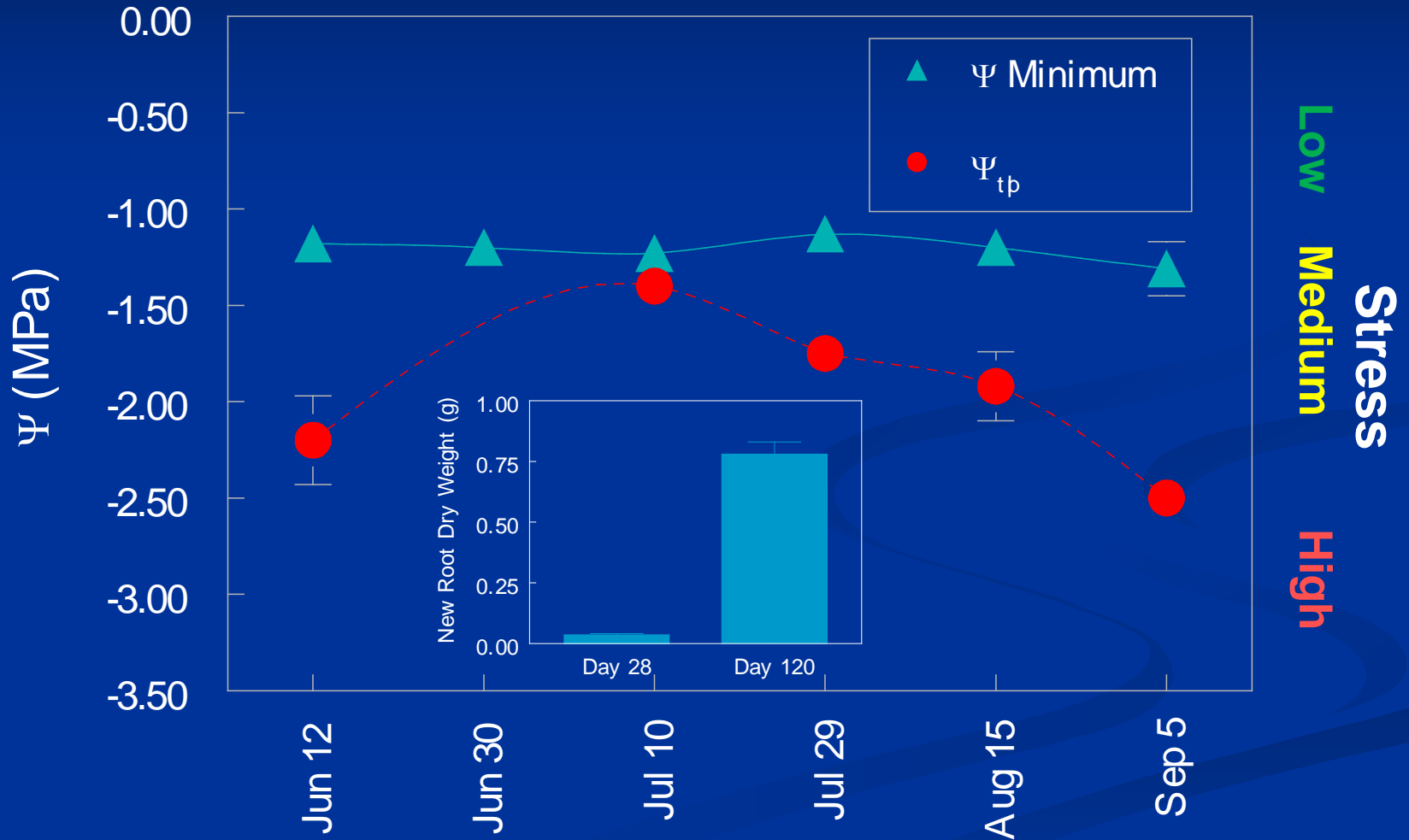
# Diurnal Seedling Response



# Severe Planting Stress

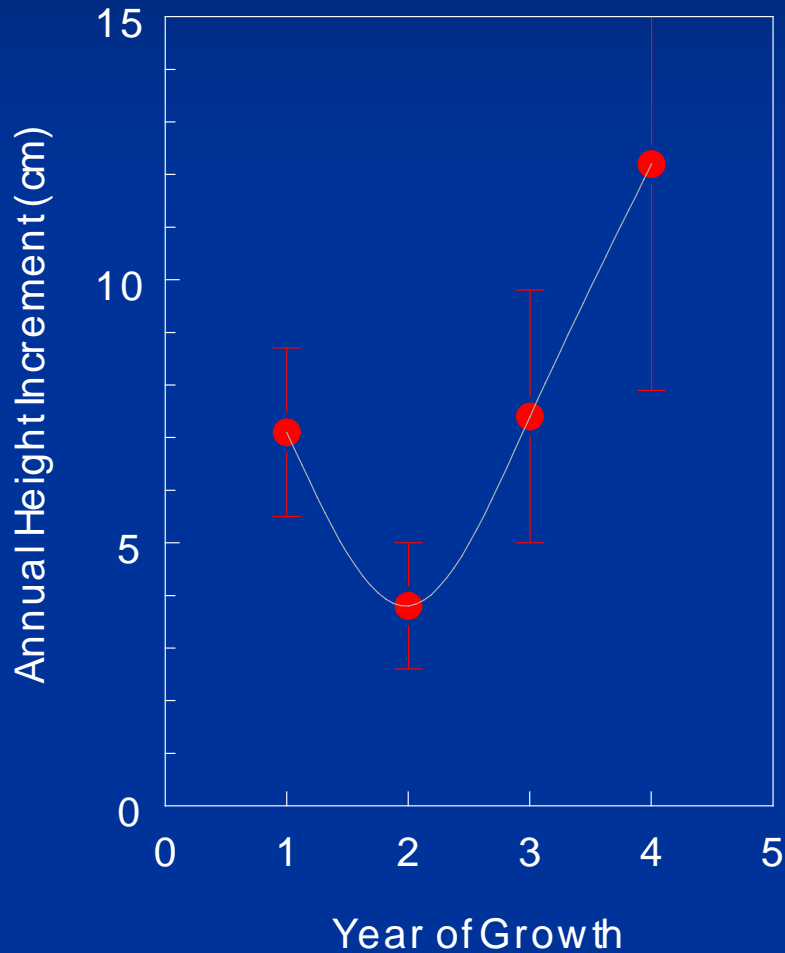


# No Planting Stress

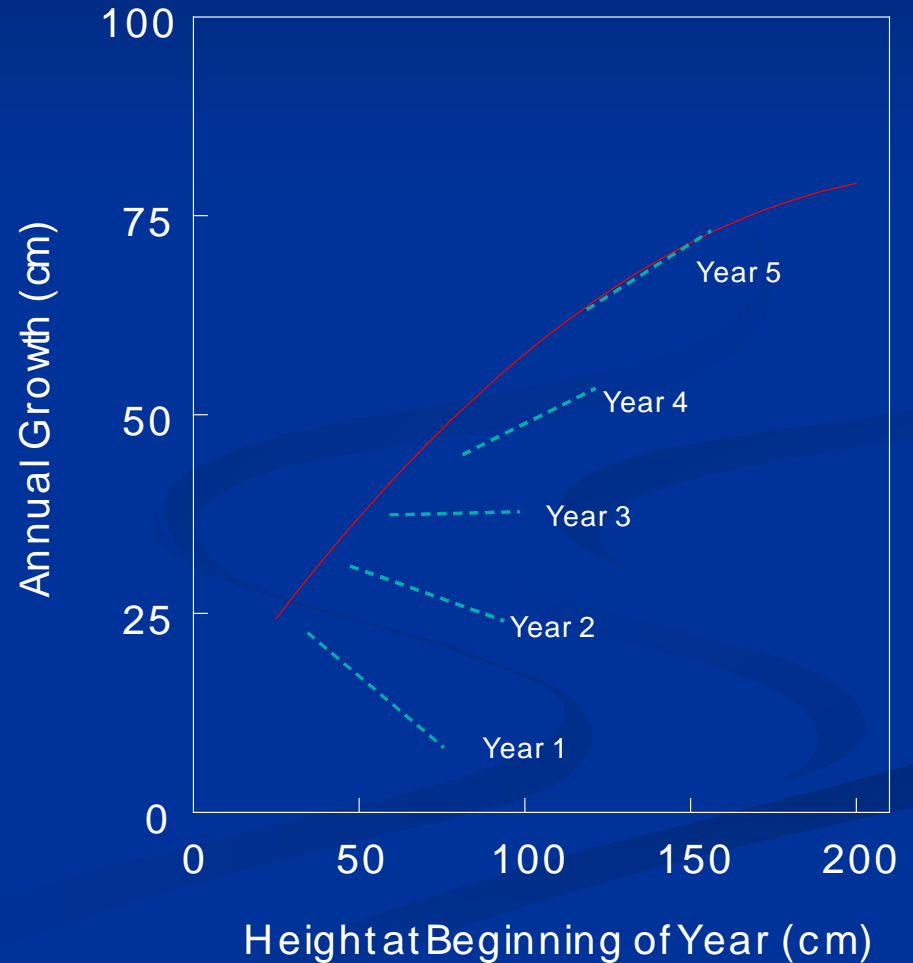




# Planting Stress - Carry Over Effect

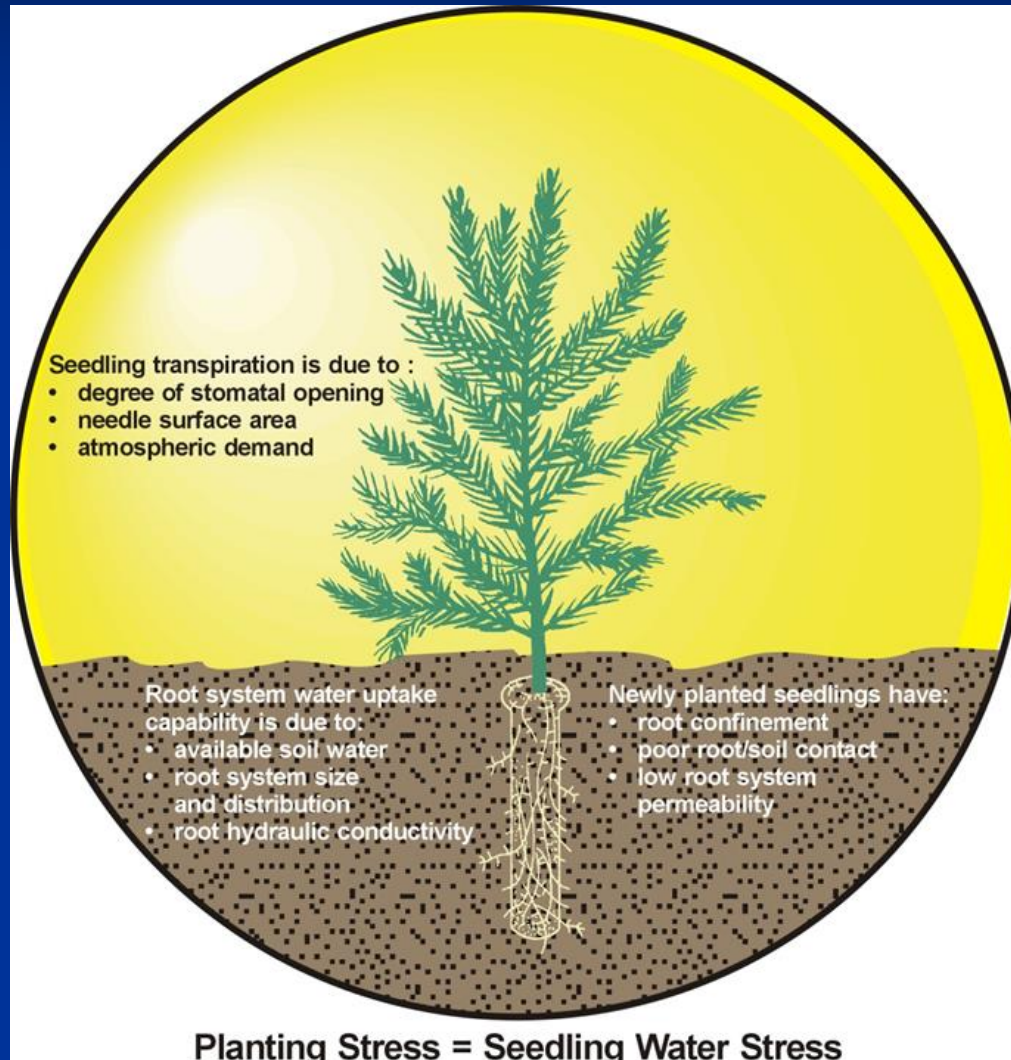


Vyse 1981



South & Zwolinski 1997

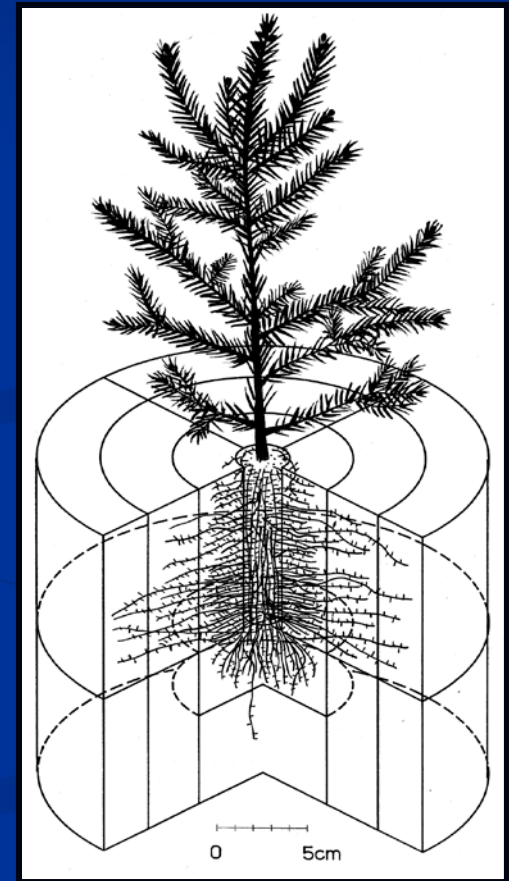
# Planting Stress



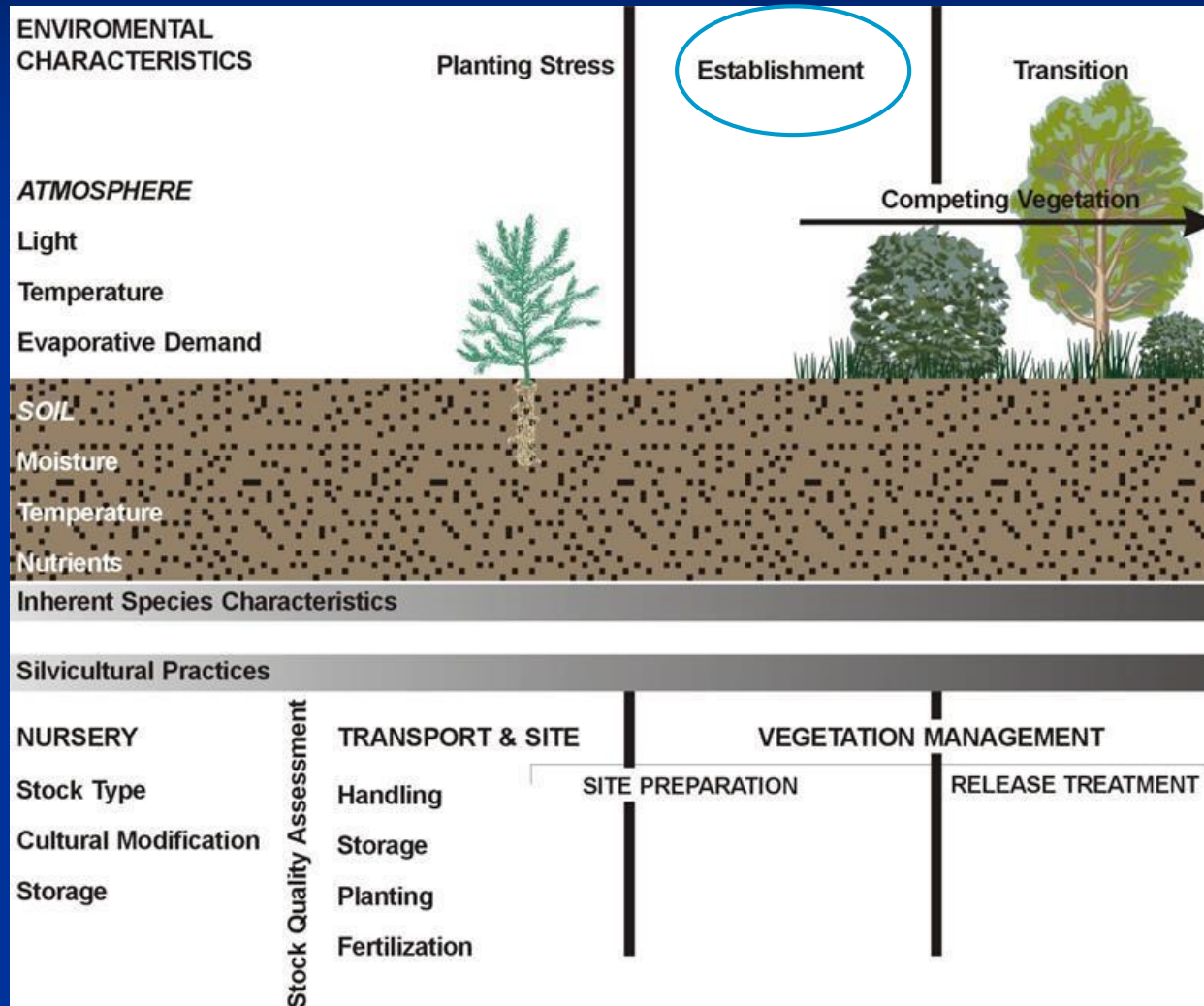
# Overcome Planting Stress by

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

***Root Growth = Coupling to Site***



# Forest Regeneration Process



# Seedling Establishment

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Seedling performance depends on:

- Inherent growth potential (i.e. Seedling Quality - morphological and physiological attributes).
- Ecophysiological response to site environmental conditions, which limit or enhance that potential.



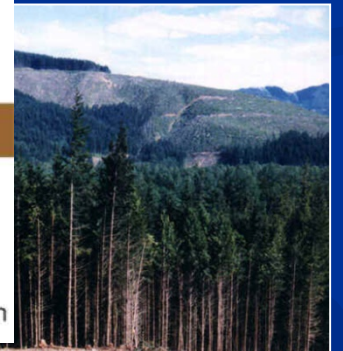
# Seedling Environment



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

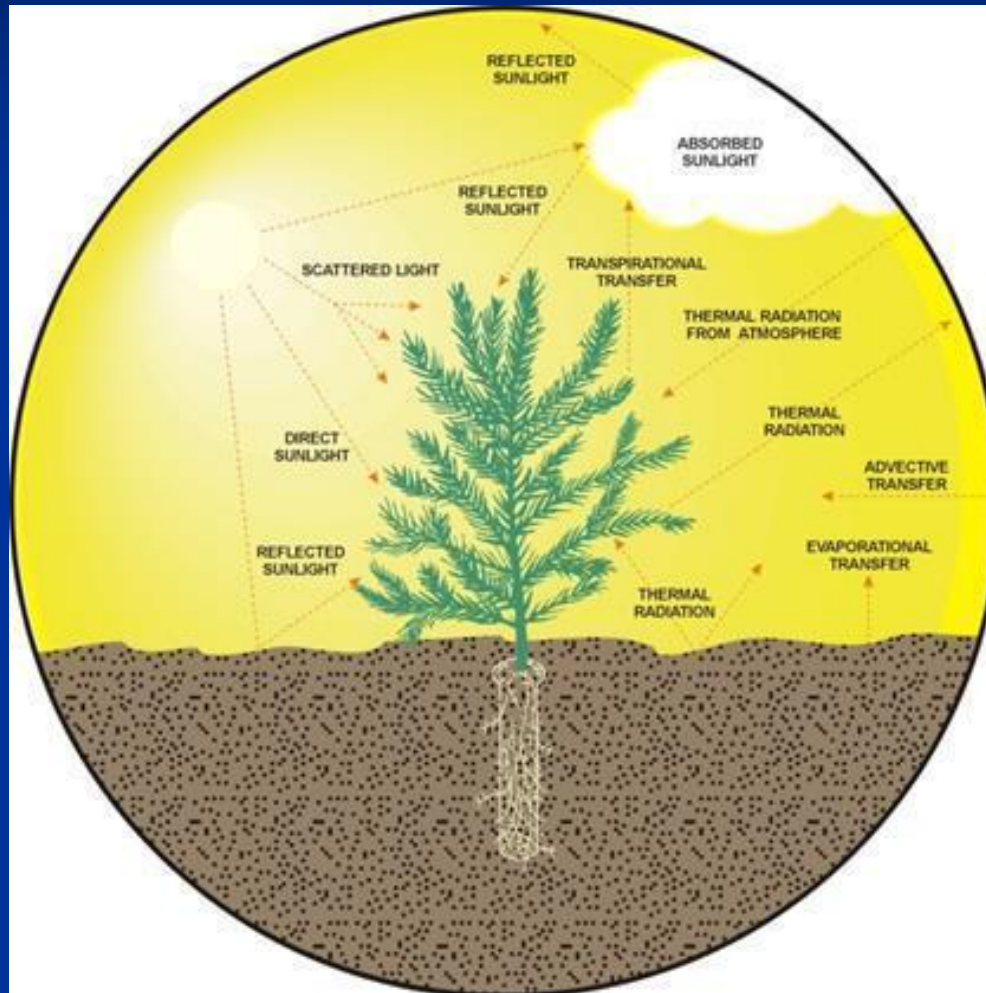
## Forest Regeneration Site

- 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





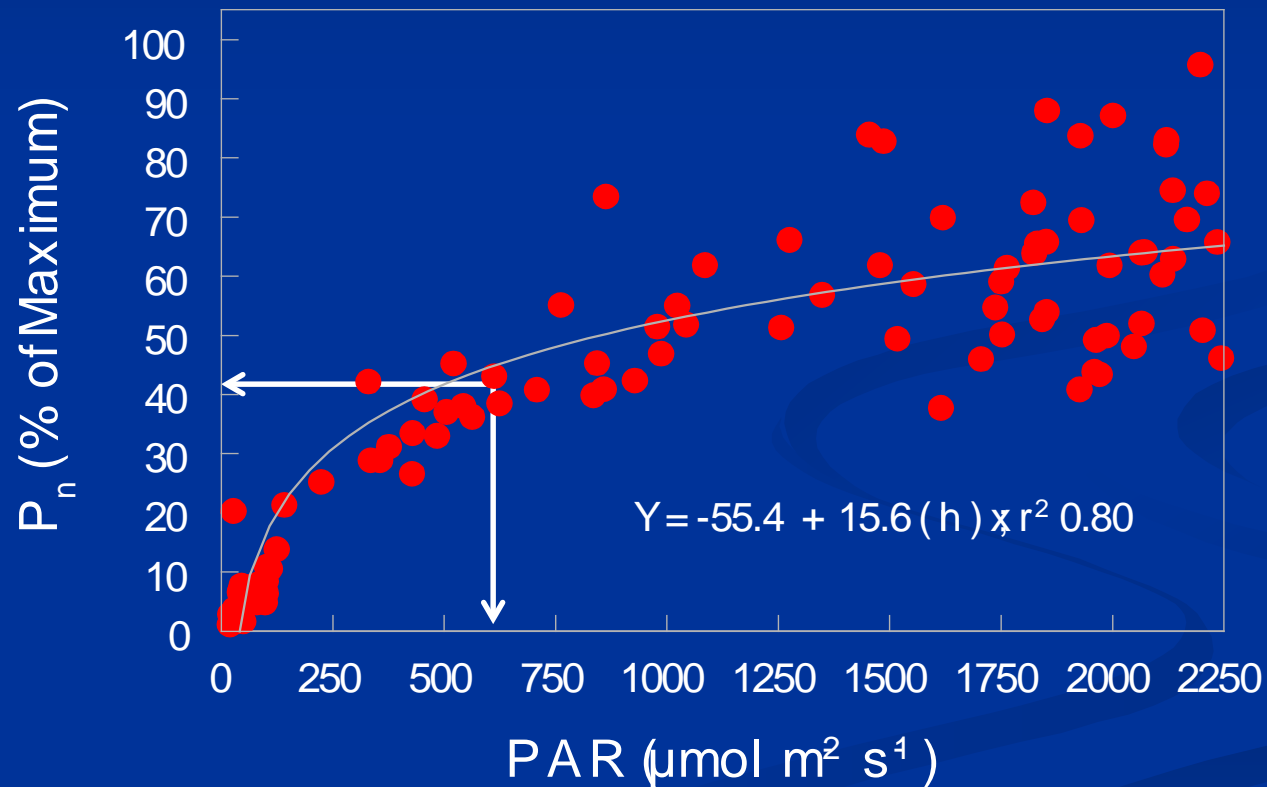
# Energy Exchange



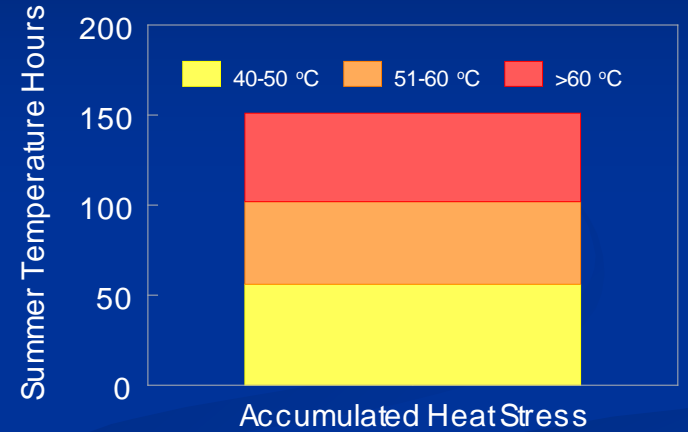
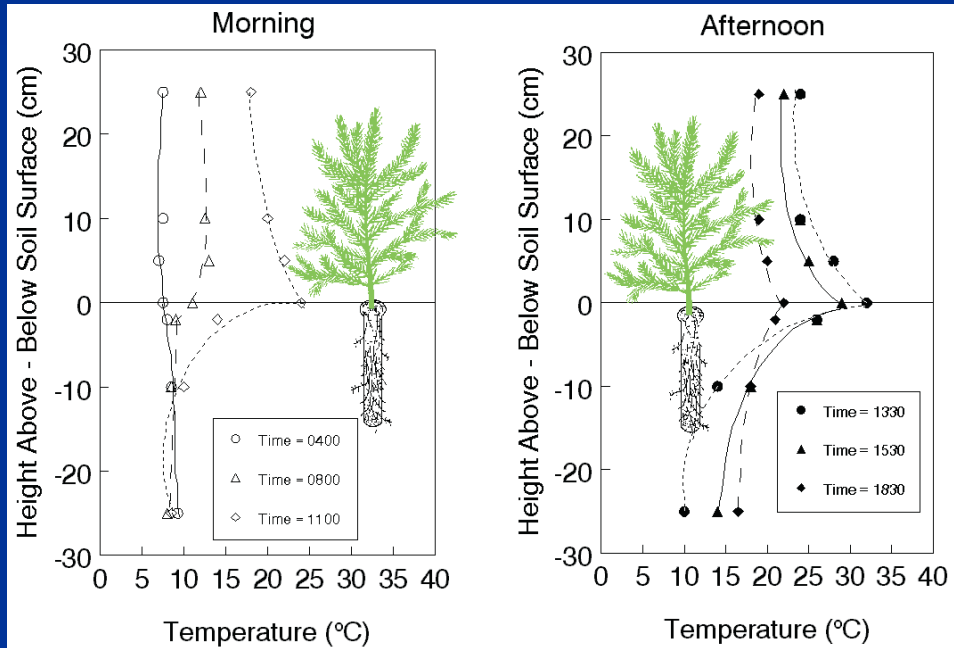
# Seedling Environment

## *Solar Radiation*

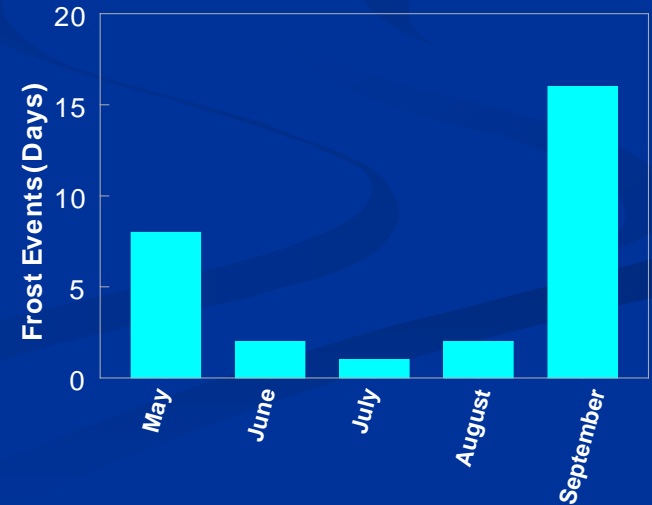
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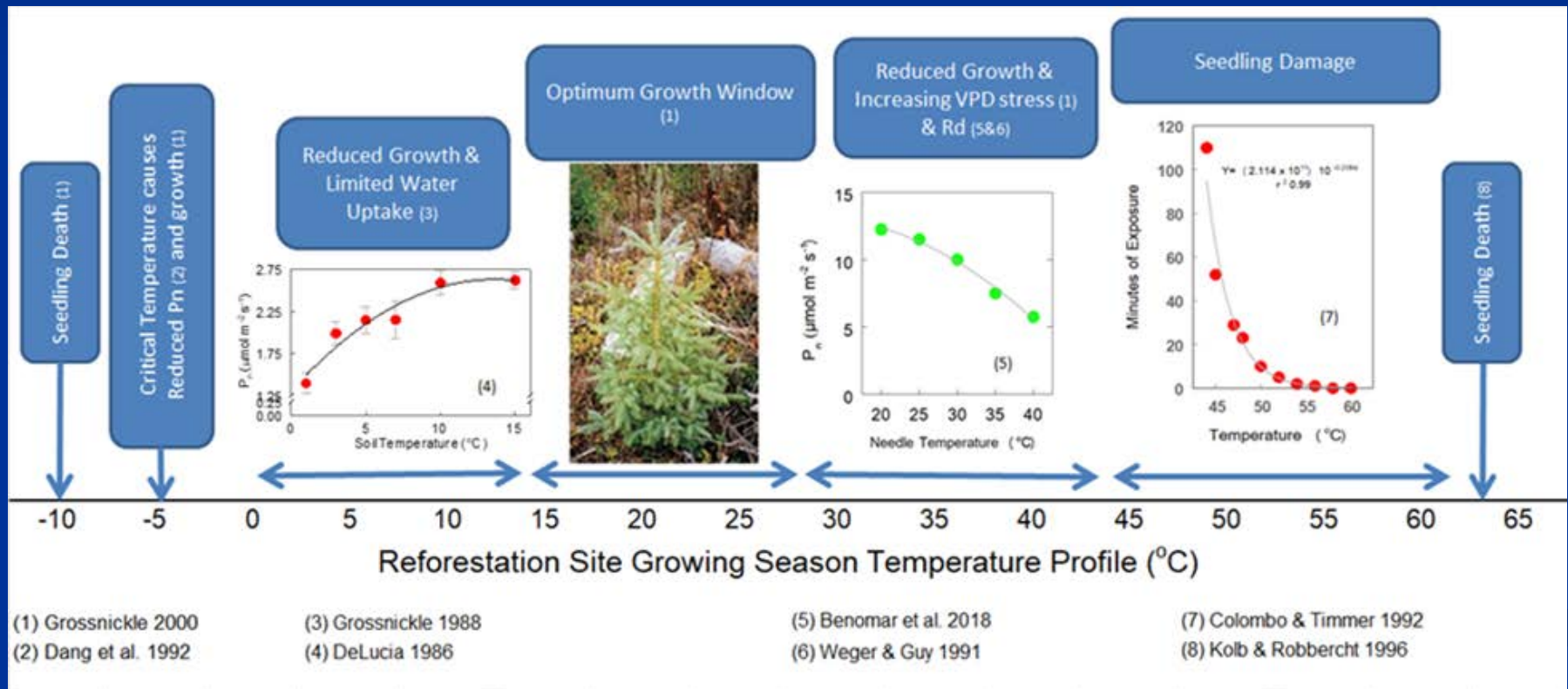
# Seedling Environment Temperature Extremes



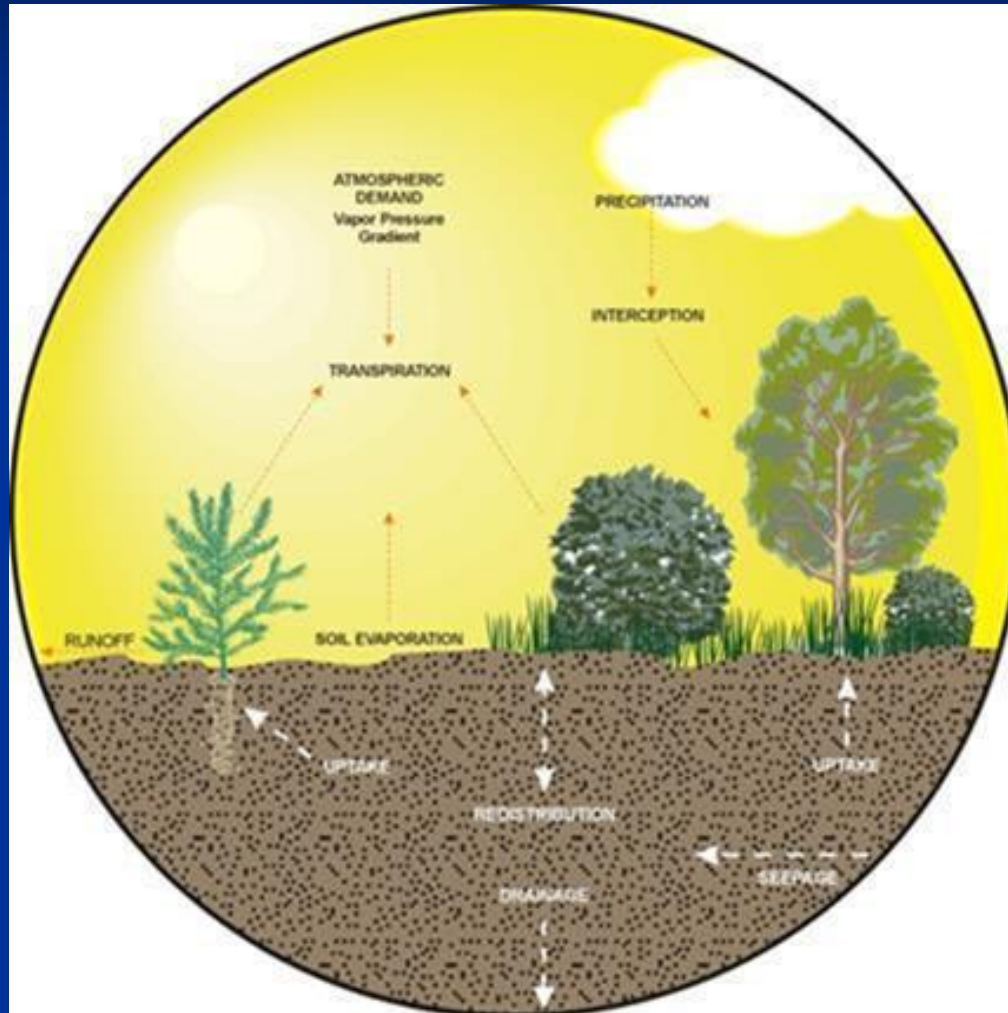
Kolb & Robberecht 1996



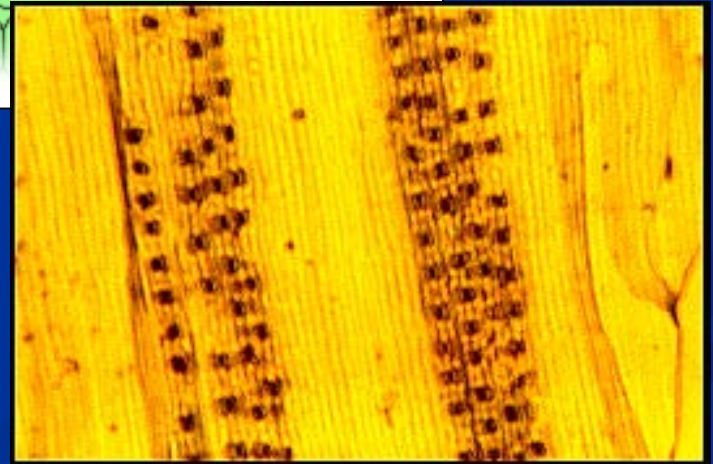
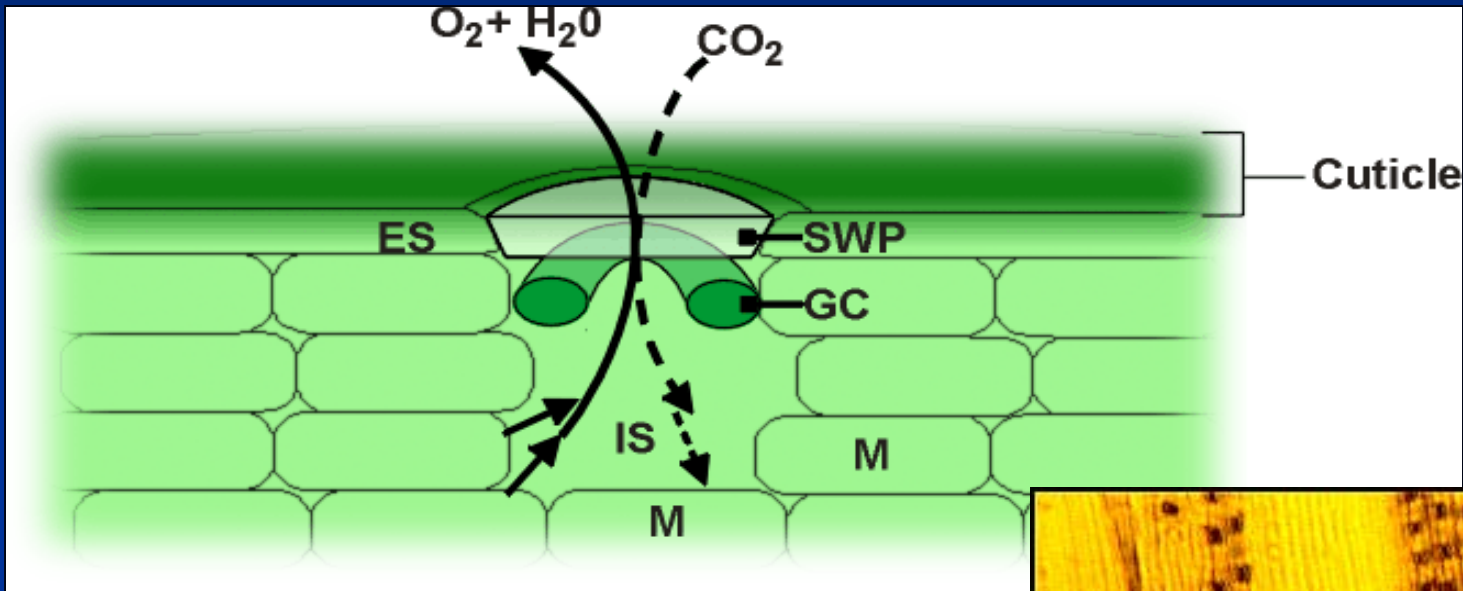
# Seedling Temperature Response



# Hydrologic Cycle



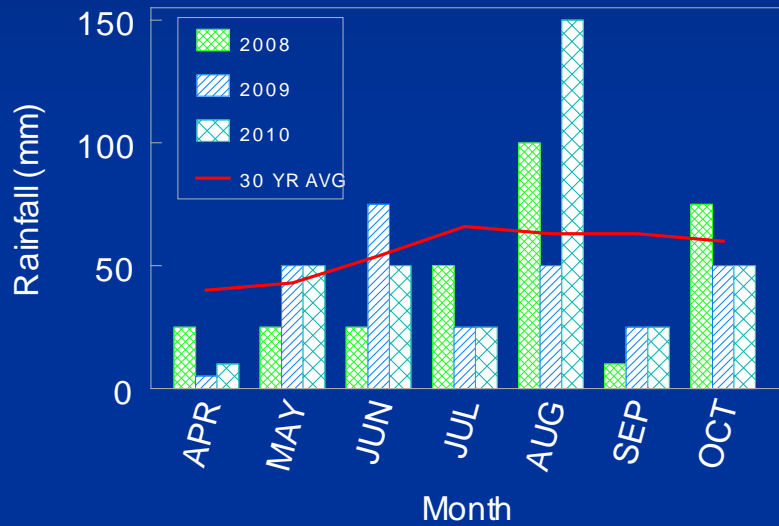
# Carbon Uptake & Water Loss



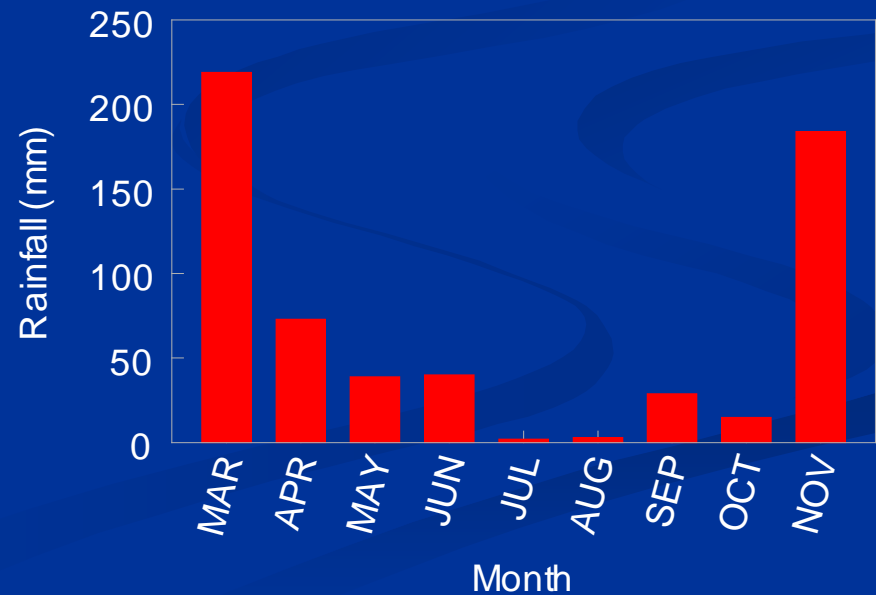


# Seedling Environment

## Seasonal Rainfall

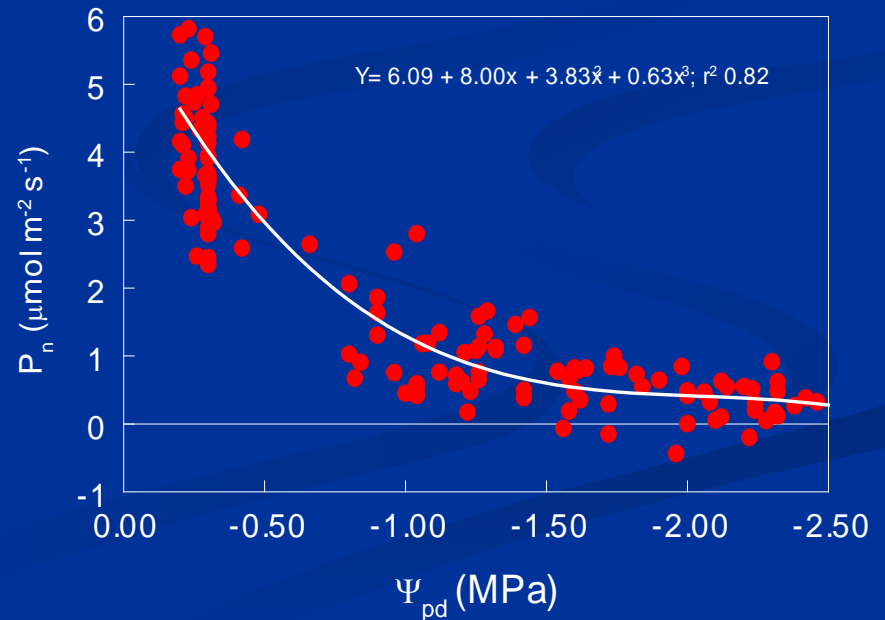
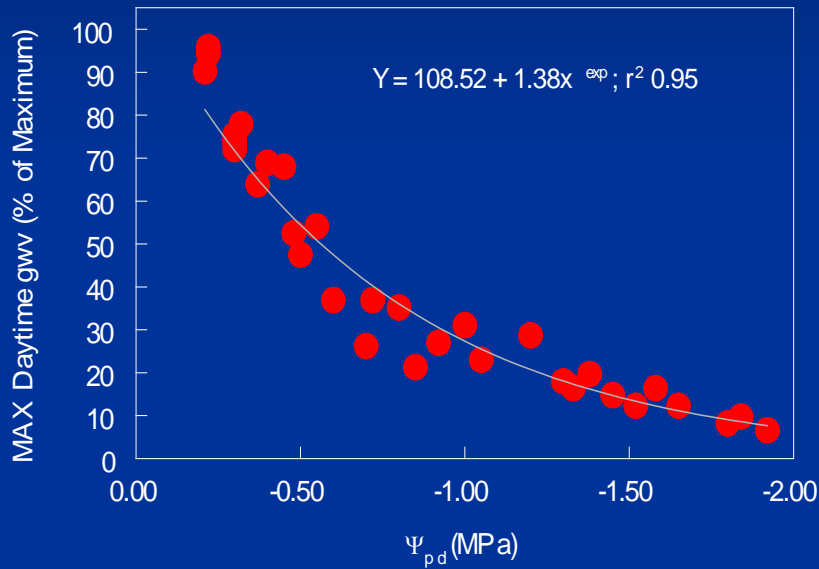


Levinsson et al. 2014

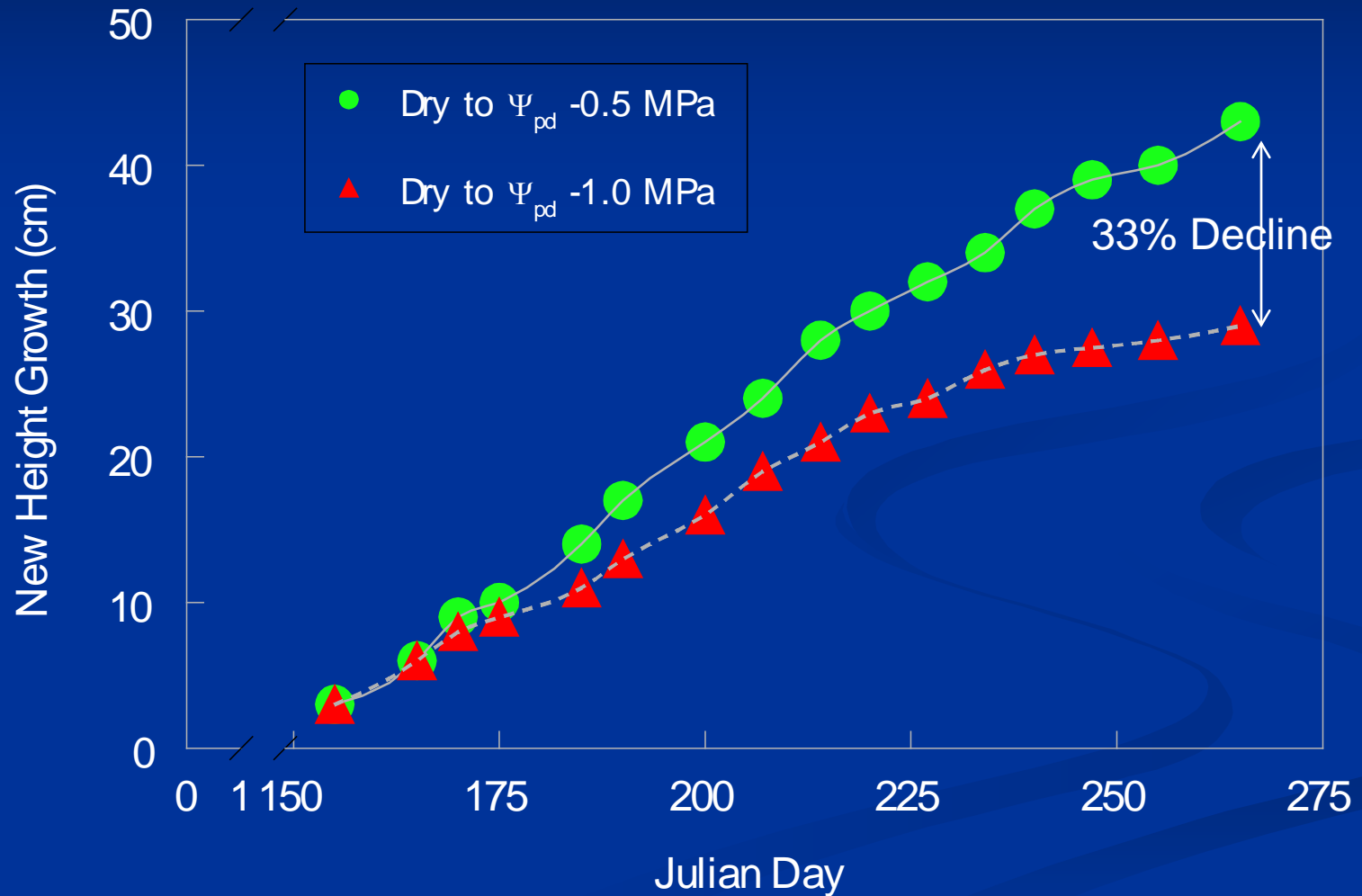


# Response to Drought

## *Gas Exchange*

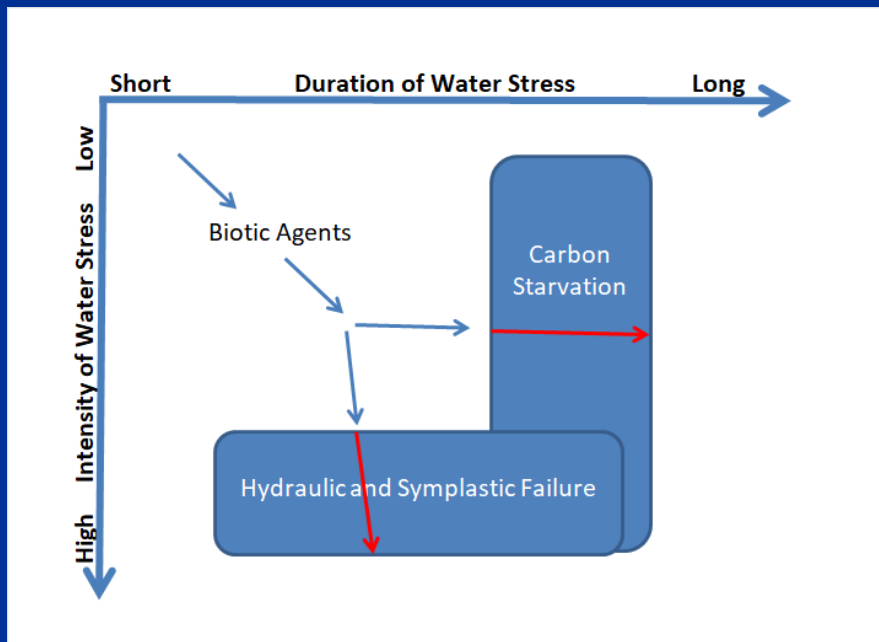


# Response to Drought *Growth*



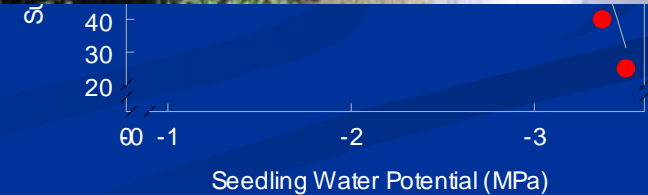
# Response to Drought

## *Lethal Level*



McDowell et al. 2008

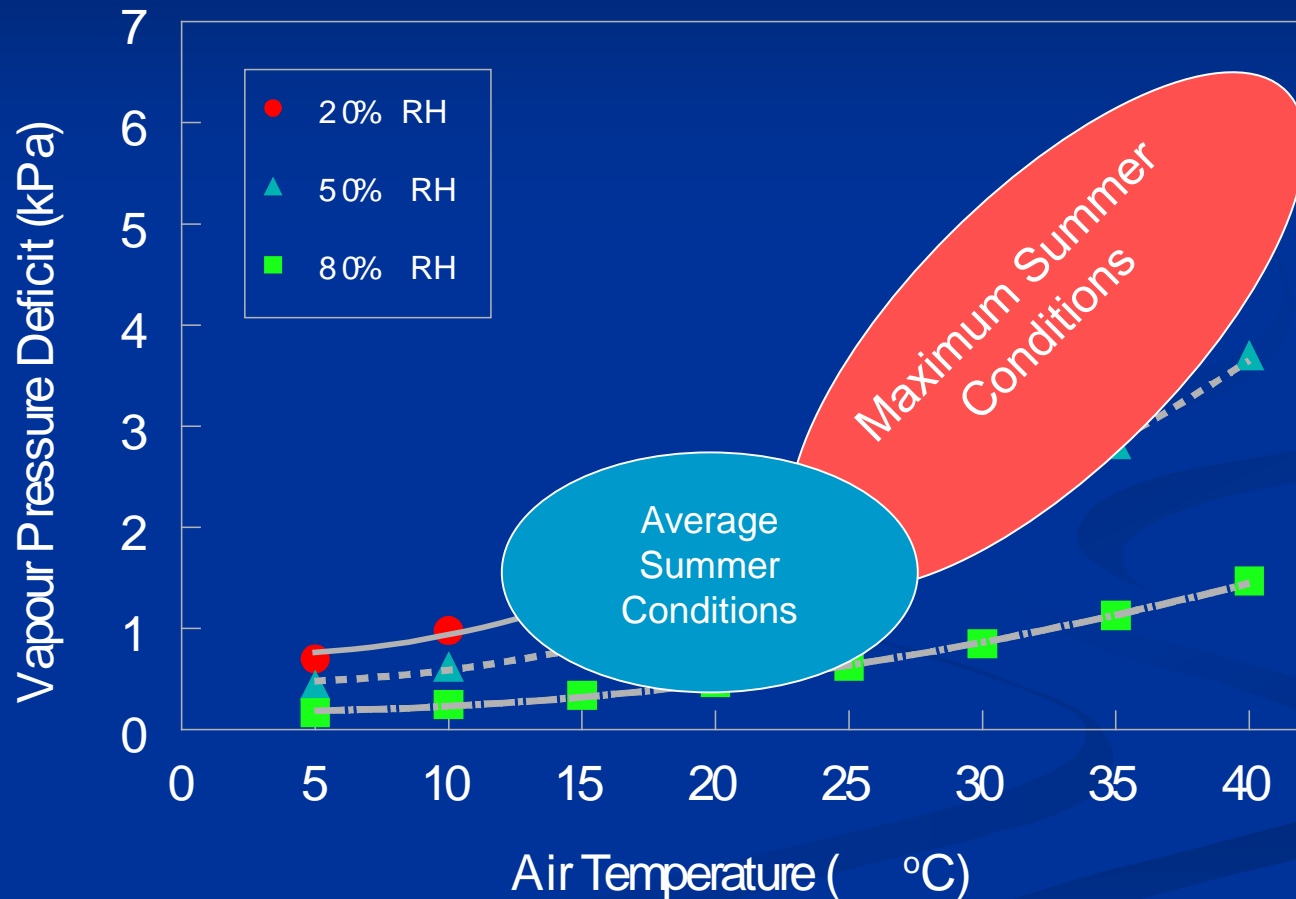
## Western Redcedar



# Seedling Environment

## VPD - *Drying Power of Air*

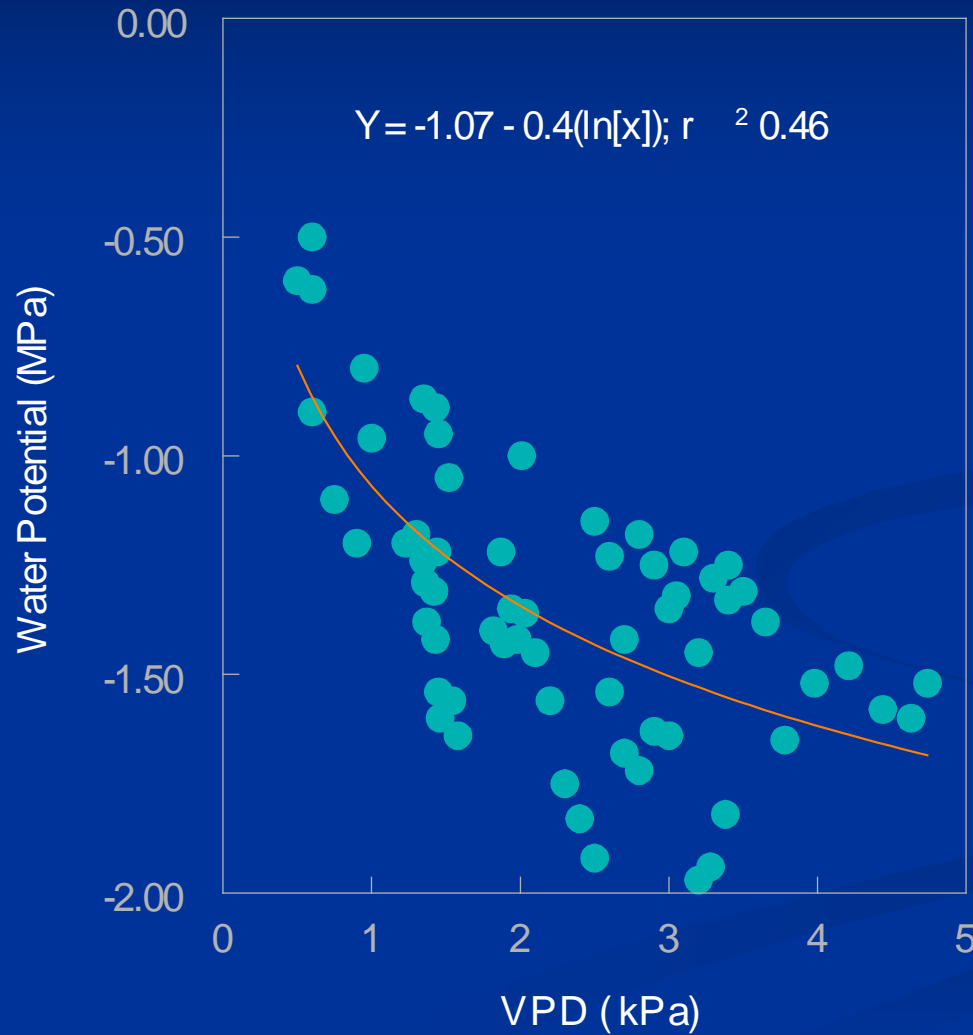
*“...heat is like a steroid, amplifying the atmosphere’s power to suck moisture from plants, soil, rivers and human skin.”*  
Carswell 2018



# Response to VPD

## *Water Status*

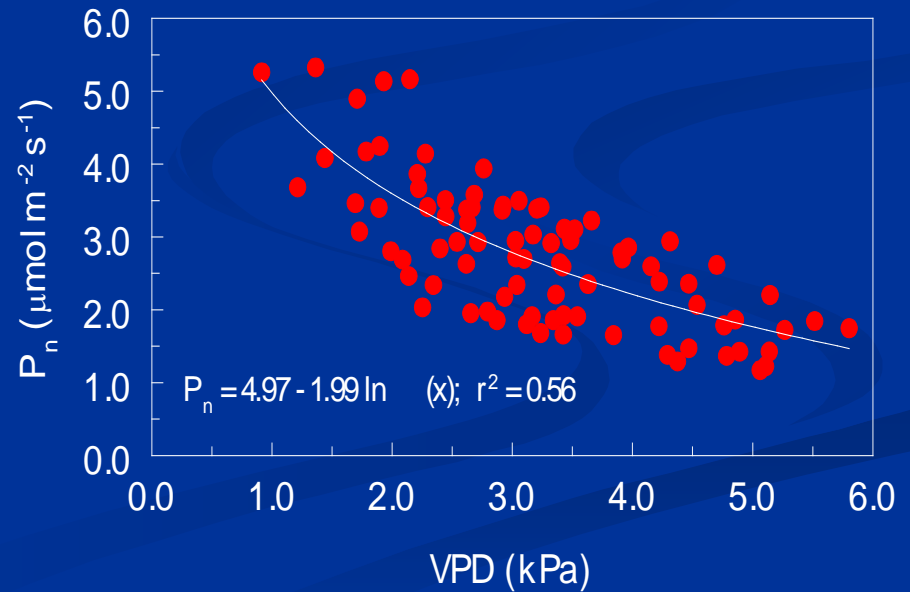
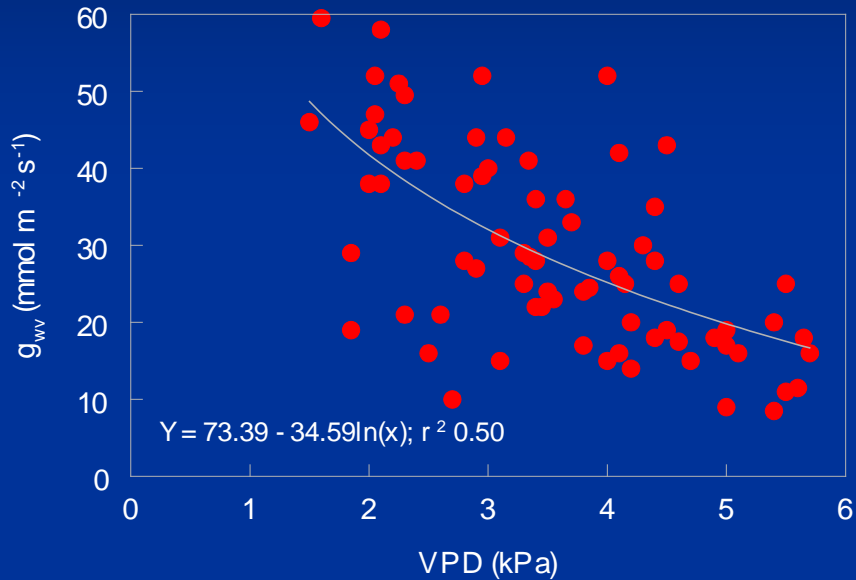
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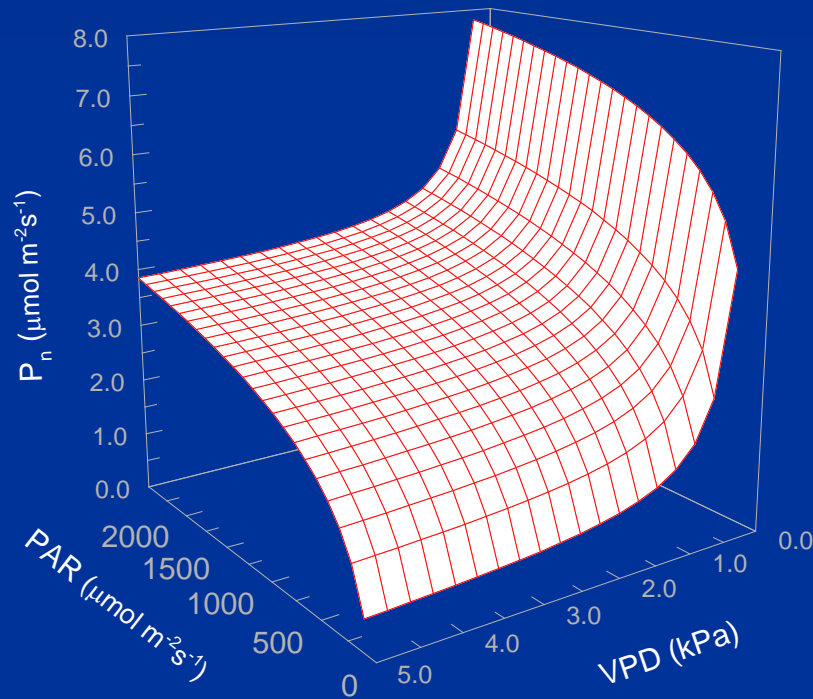
# Response to VPD

## *Gas Exchange*

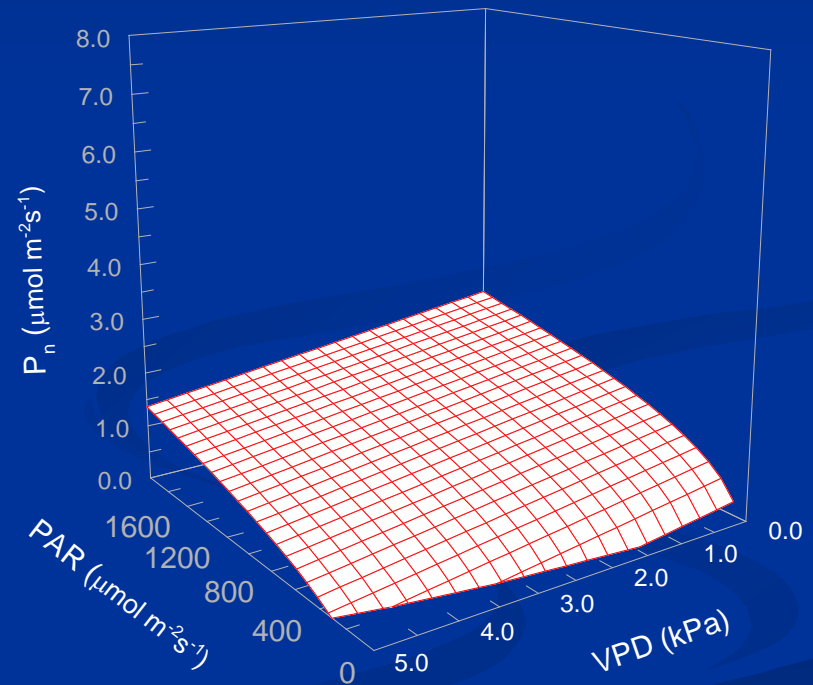


# Response to Multiple Factors

Atmospheric Response

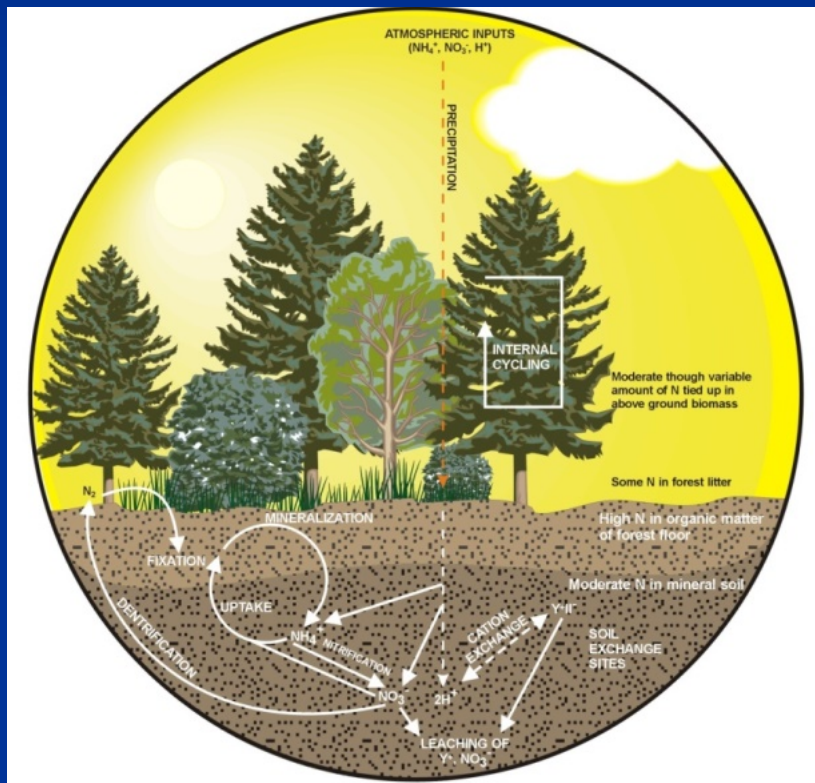


Atmospheric & Edaphic Response

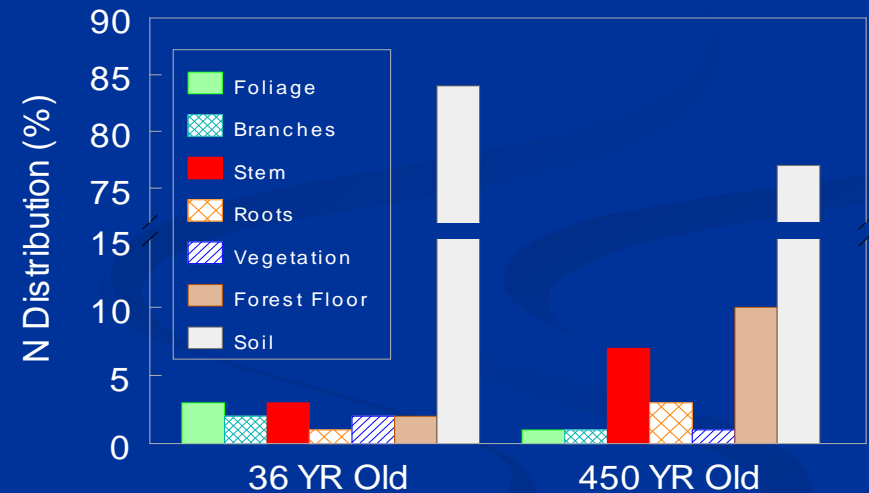


# Seedling Environment

## Nutrient Cycle



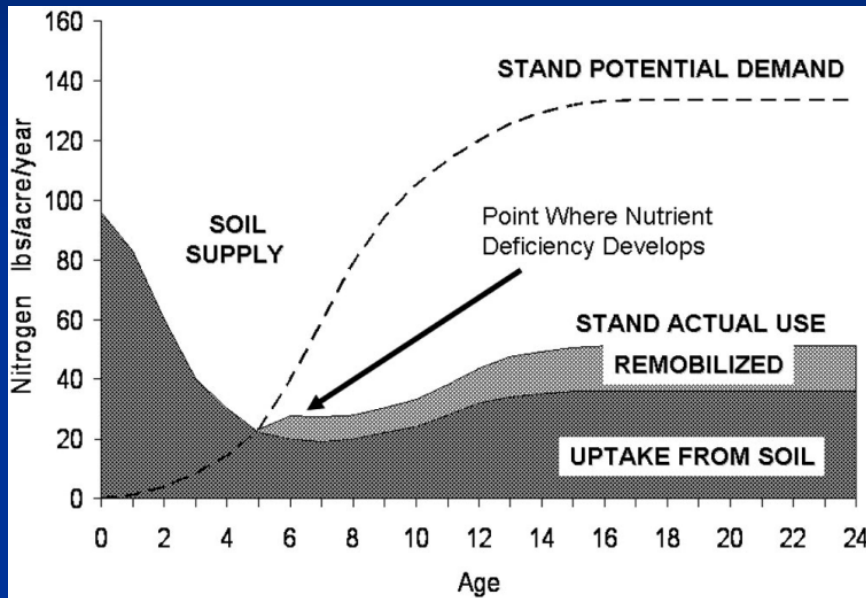
Coastal Douglas-Fir Ecosystems



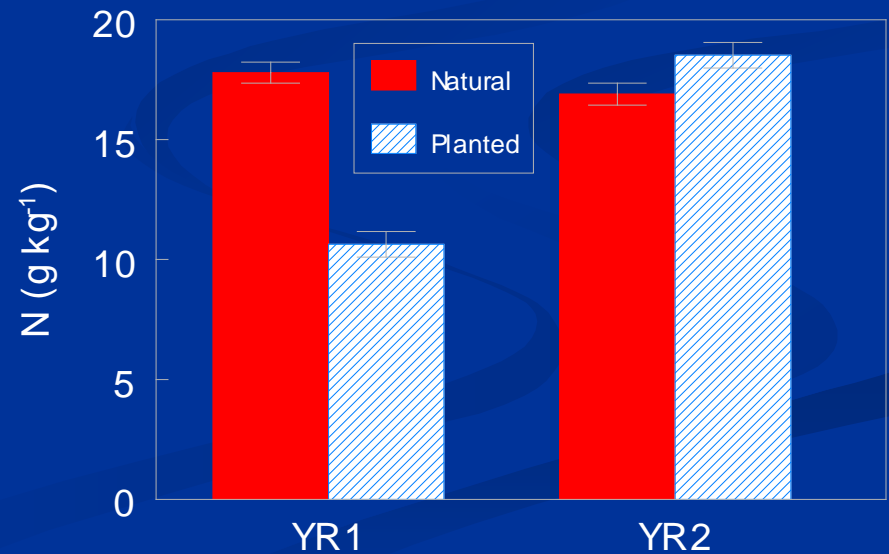
Johnsen et al. 1982

# Nutrient Cycle

## *Are limitations an issue?*

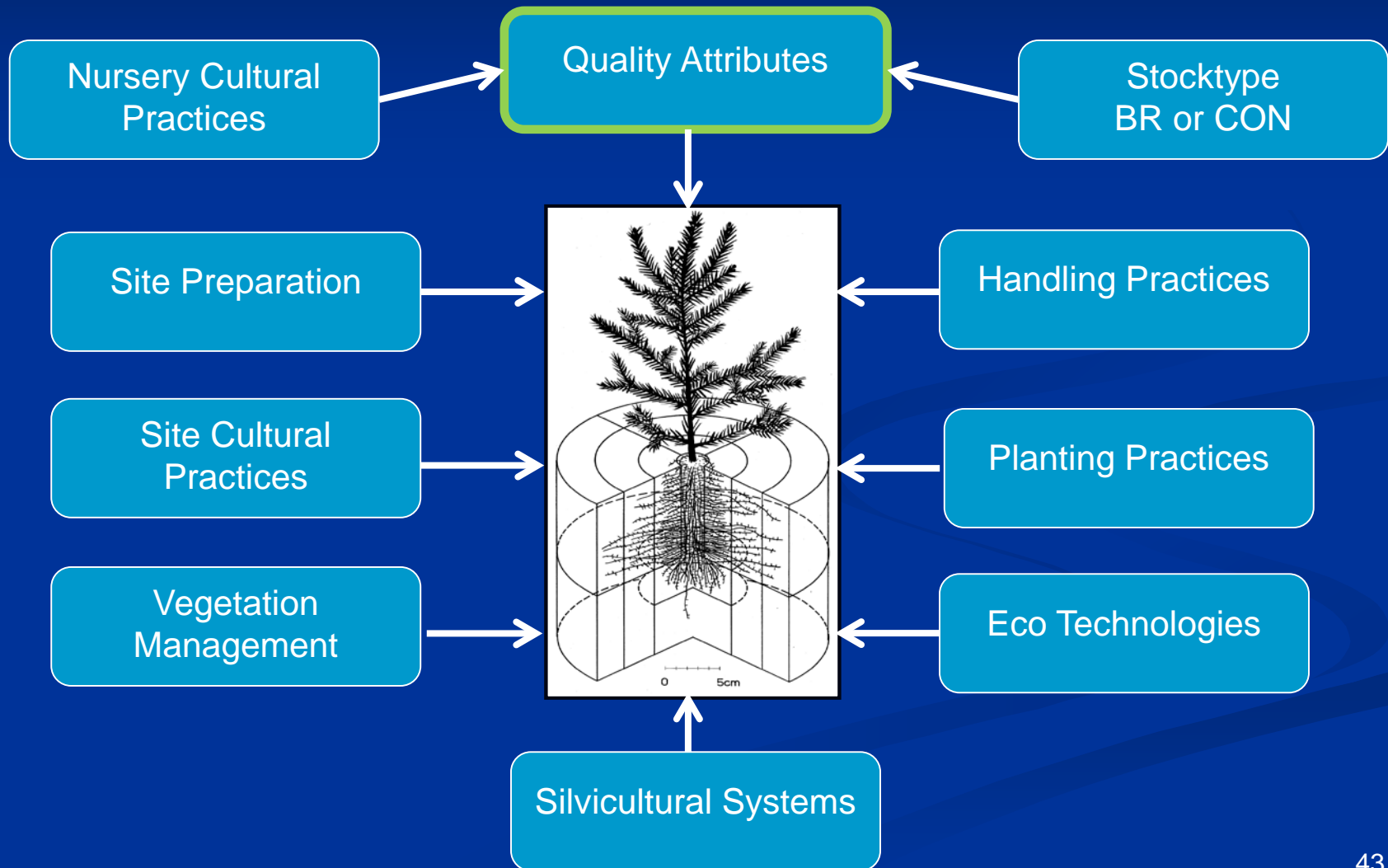


(Fox et al. 2006)

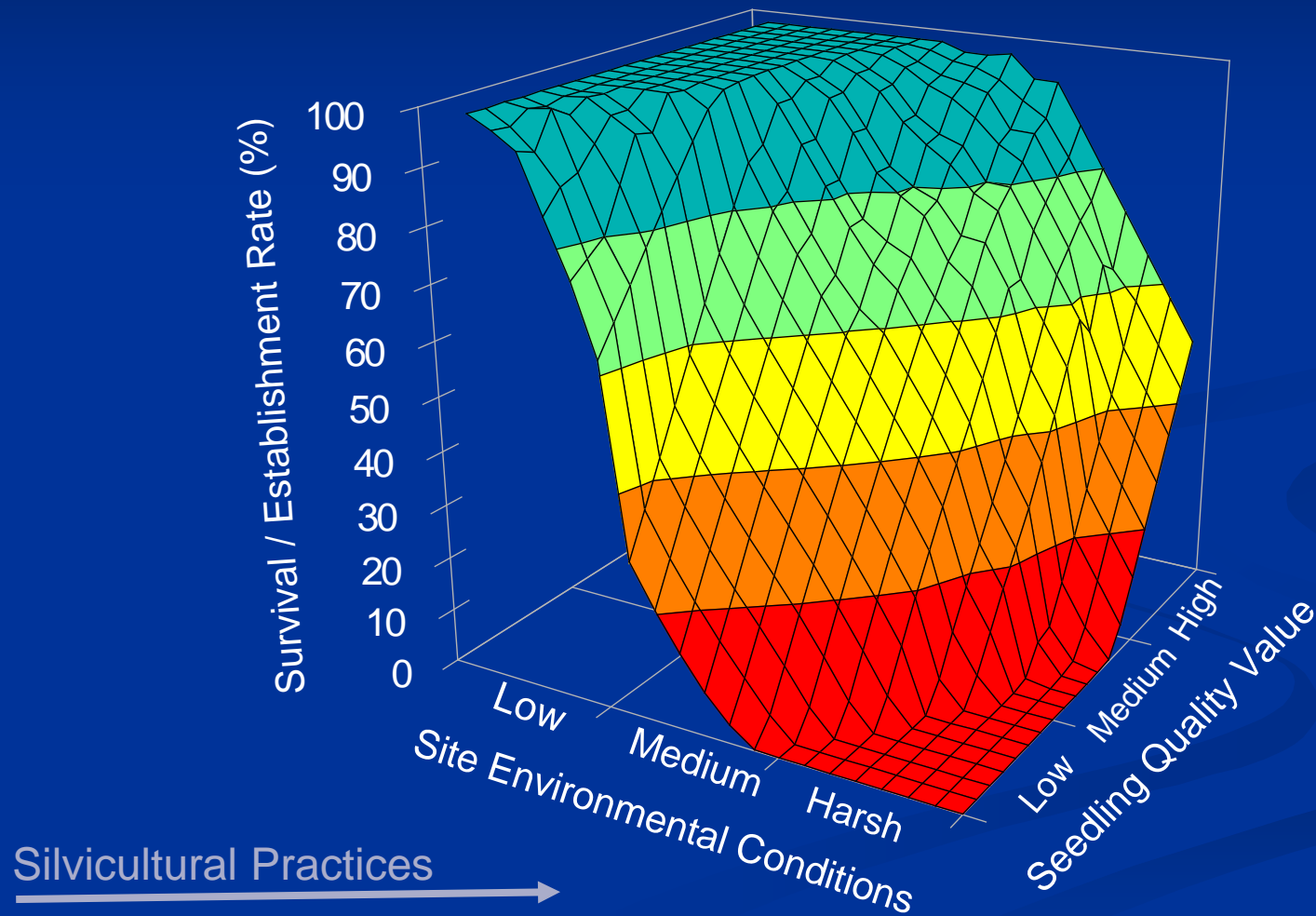


Munson and Bernier 1993

# Seedling Establishment



# Seedling Establishment





# Closing Thoughts

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- Planting Stress
  - *It is real, so be aware of the issue.*
- Establishment Phase
  - *Understand site effects on tree species ecophysiological response.*
- Silvicultural Practices
  - *Intent to create desirable field site conditions.*
- Seedling Quality
  - *A critical decision controlled by Foresters.*