



Nursery practices and their importance to outplanting success

Ryan Nadel



Introduction

- Optimal growing conditions in a nursery
 - Irrigation
 - Fertilization
 - Etc.
- Optimal Nursery environment does not equate to a harsh planting environment
 - Physiology
 - Morphology
 - Anatomy

Introduction

- Drought conditioning seedlings
 - To intentionally limit irrigation during the growth phase in a nursery
- Determine whether there is difference in the plant physiology, morphology and anatomy that promotes vigor and survival in a water stressed environment
 - Nursery
 - Field

Measurements

Morphological

- Height
- RCD
- Shoot Weight
- Root Weight
- Root Weight Ratio

Physiological

- Stomatal conductance
- Photosynthetic rate
- Non structural carbohydrates (soluble sugars and starch)

Anatomy

- Hydraulically active xylem vessels
- Root hydraulic conductance



Root health and hydraulic conductivity and its importance to outplanting success

Ryan Nadel, Lisa Samuelson



Root Phenology

- Aboveground phenology is typically separated into discrete events such as budburst and leaf senescence.
- Onset and progression of root phenology do not simply track aboveground phenology.
- Unlike shoots, roots do not experience winter dormancy.

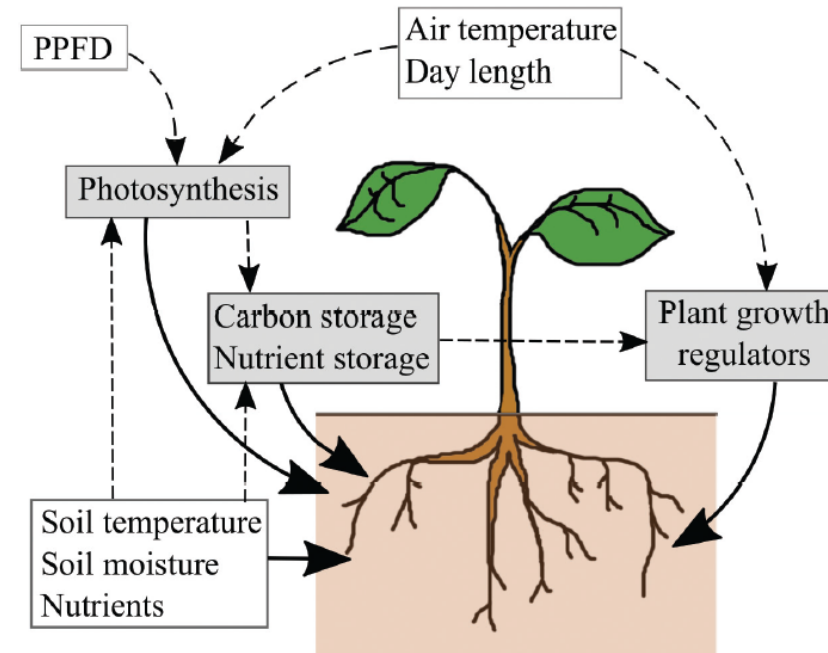
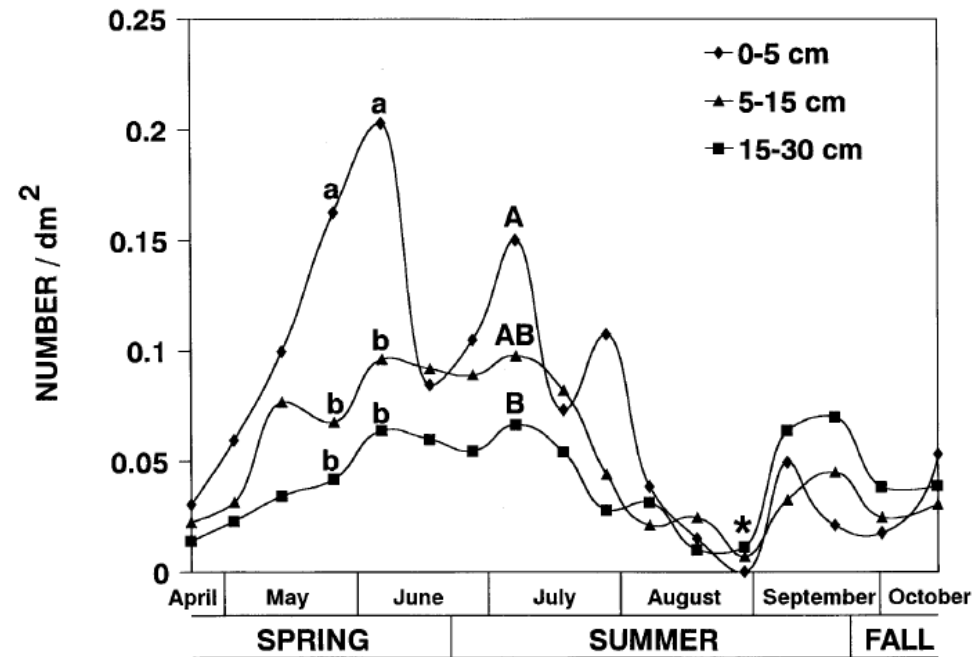


Fig. 1. Potential controls over root phenology. Solid lines indicate direct controls and dashed lines indicate indirect controls on root phenology. Gray boxes represent endogenous controls; and white boxes represent exogenous controls. PPFD is photosynthetically active flux density.

Root Phenology in a Changing Climate

- Drivers of autumn root phenology not well understood.
- Root growth may slow as soil temperature and plant carbohydrate availability decrease.
- Photoperiod not a strong control.
- Root growth can occur year round if conditions favorable.
- In southern US, seedlings in nursery beds can increase RCD and root growth in winter. *Unsuberized roots more vulnerable to mechanical injury and desiccation.*

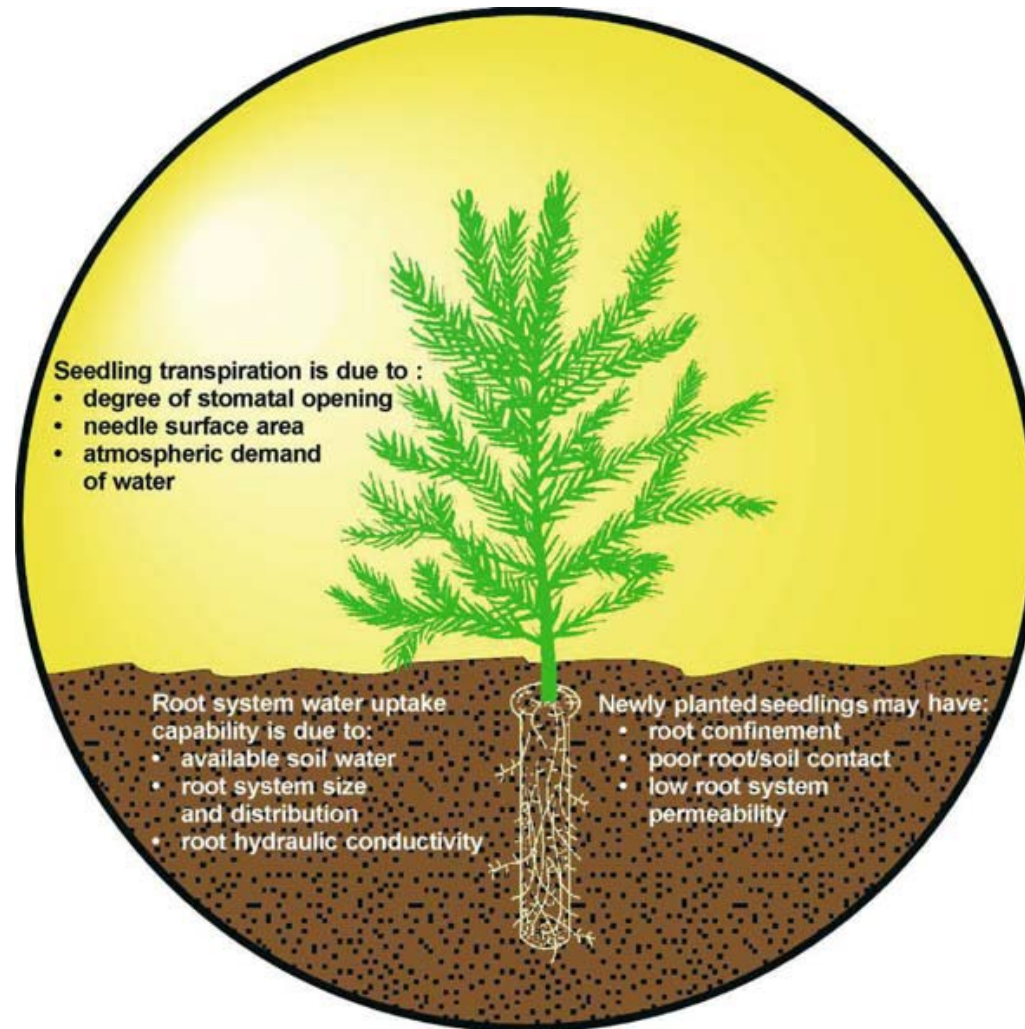
Loblolly Pine Root Growth



- Root phenology patterns related to photosynthate availability

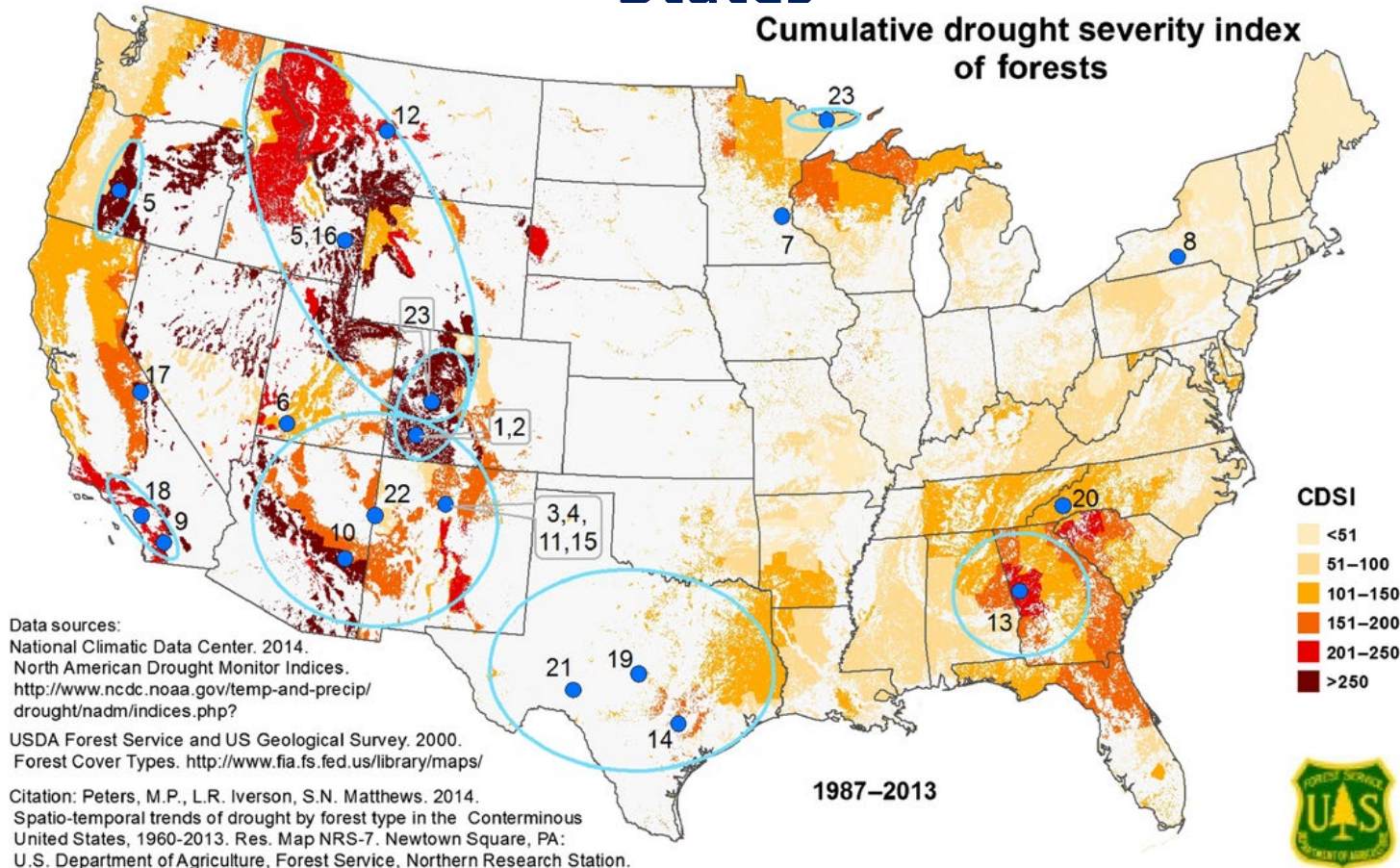
Figure 4. Mean number of roots dm^{-2} initiated at 0–5, 5–15 and 15–30 cm in rhizotrons during April through September 1993. Within measurement intervals, means associated with the same letter are not significantly different by the LSD test at $P < 0.05$ (lower case), and $P < 0.10$ (upper case). The asterisk between August and September data denotes: 0–5 cm (b), 5–15 cm (ab) and 15–30 cm (a).

Surviving Drought



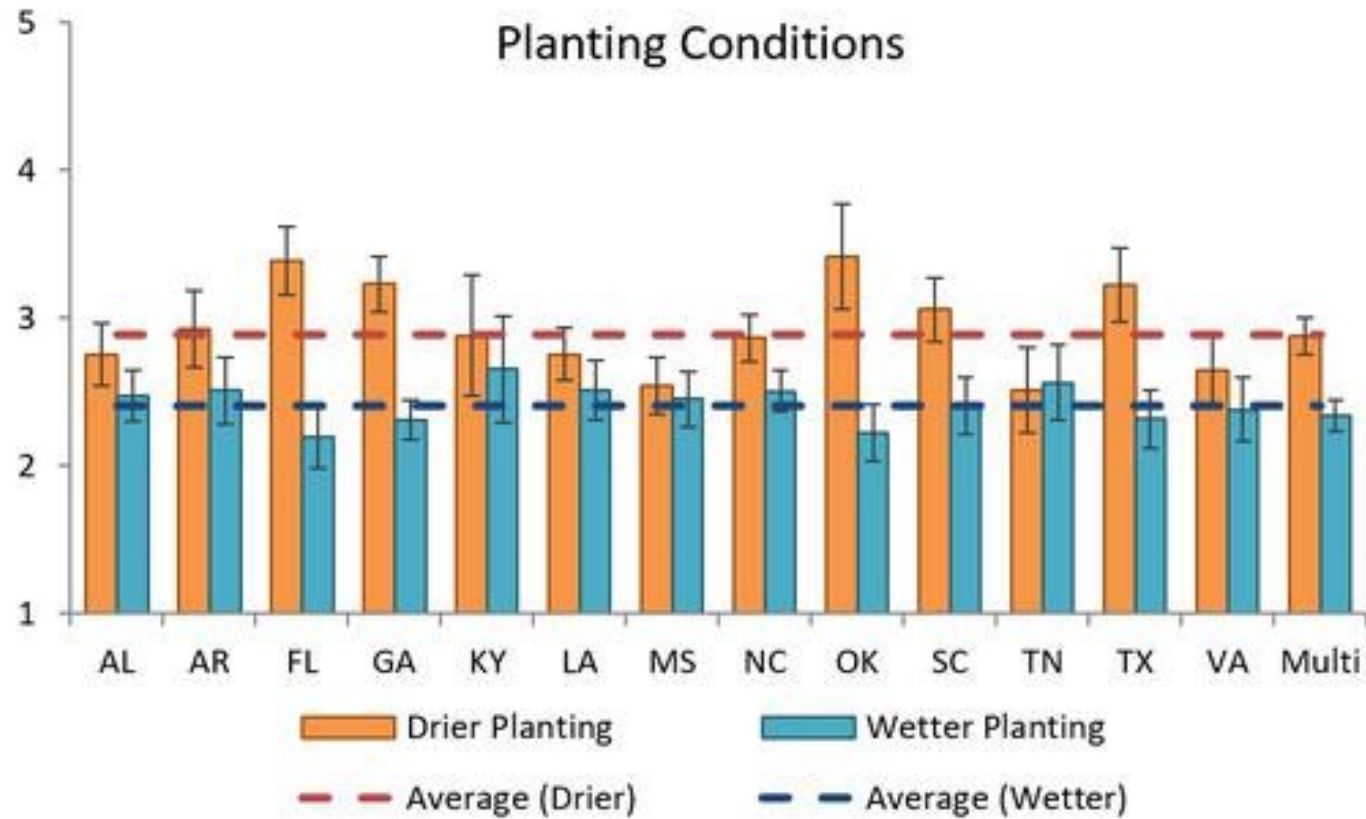
Grossnickle (2005)

The Impacts of Increasing Drought on Forest Dynamics, Structure, and Biodiversity in the United States

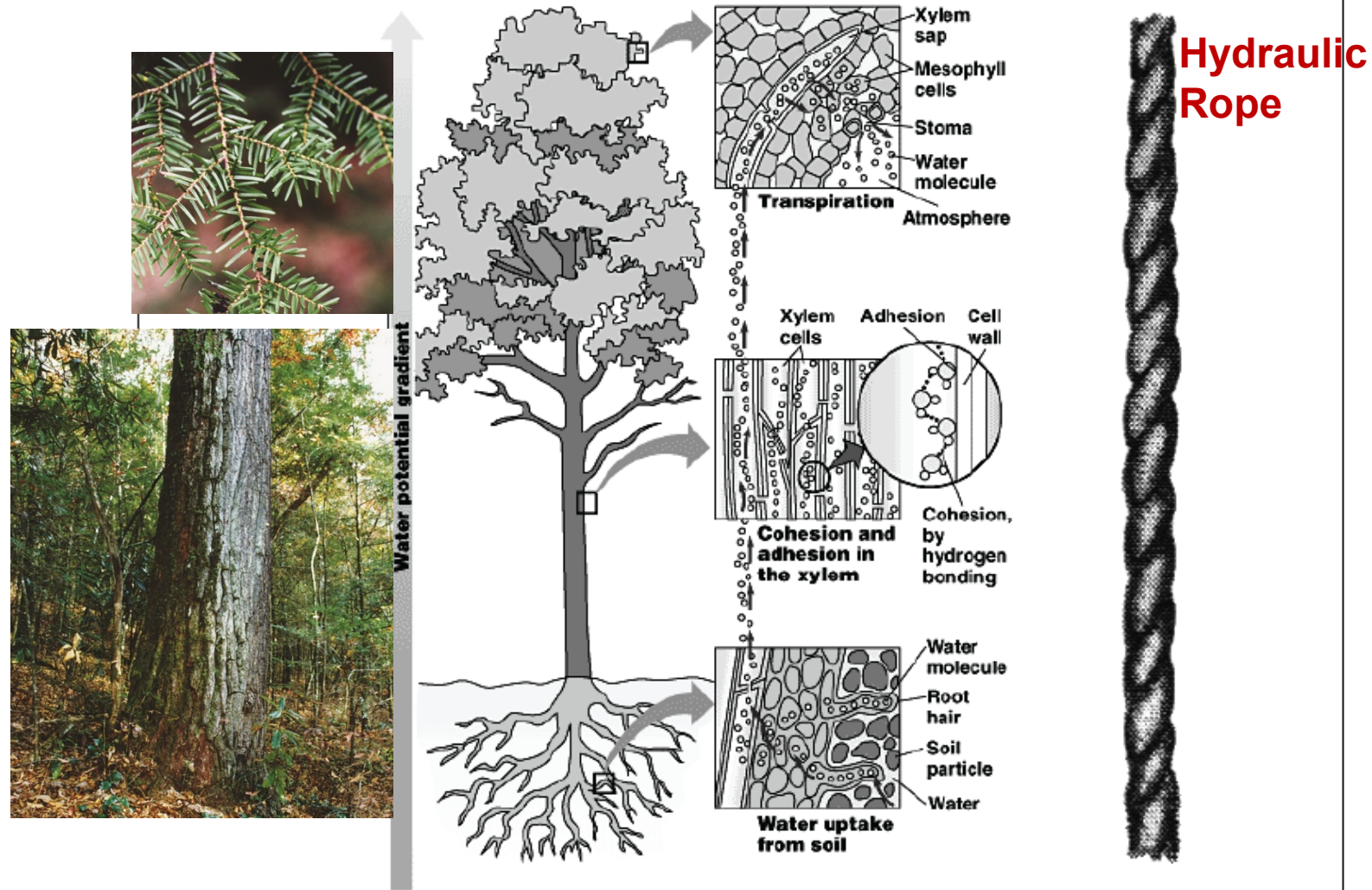


Cumulative drought severity index (CDSI) for forested lands from 1987 to 2013, (modified from Peters *et al.*, 2014), with selected locations of drought- and heat-induced tree mortality indicated by blue circles

Southern Foresters Report Drier Planting Conditions

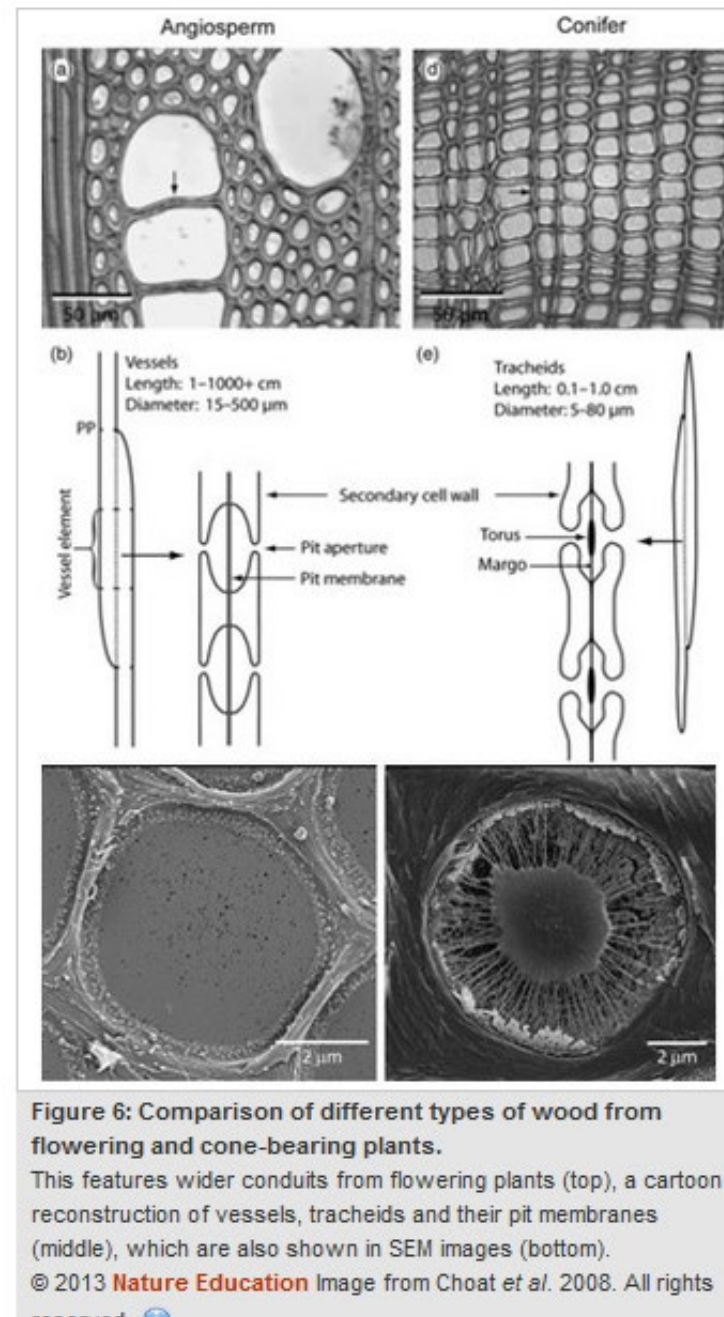


Soil-plant-atmosphere continuum



Xylem Cavitation and Embolism

- Breakage of the xylem water column due to water stress or injury.
 - Entry of air into the xylem conduits.
 - Embolisms move primarily through the pit membranes.
- Species and individuals differ in their vulnerability to cavitation – trade-offs between vulnerability and water flow.
- Size, structure and number of pits important traits.



How Embolisms Spread

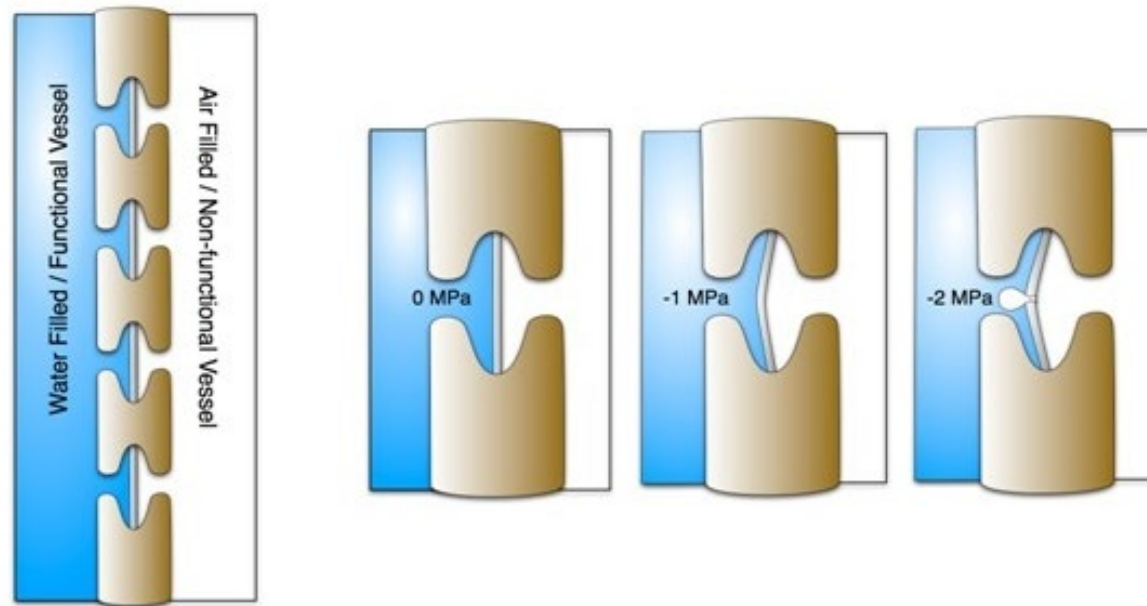
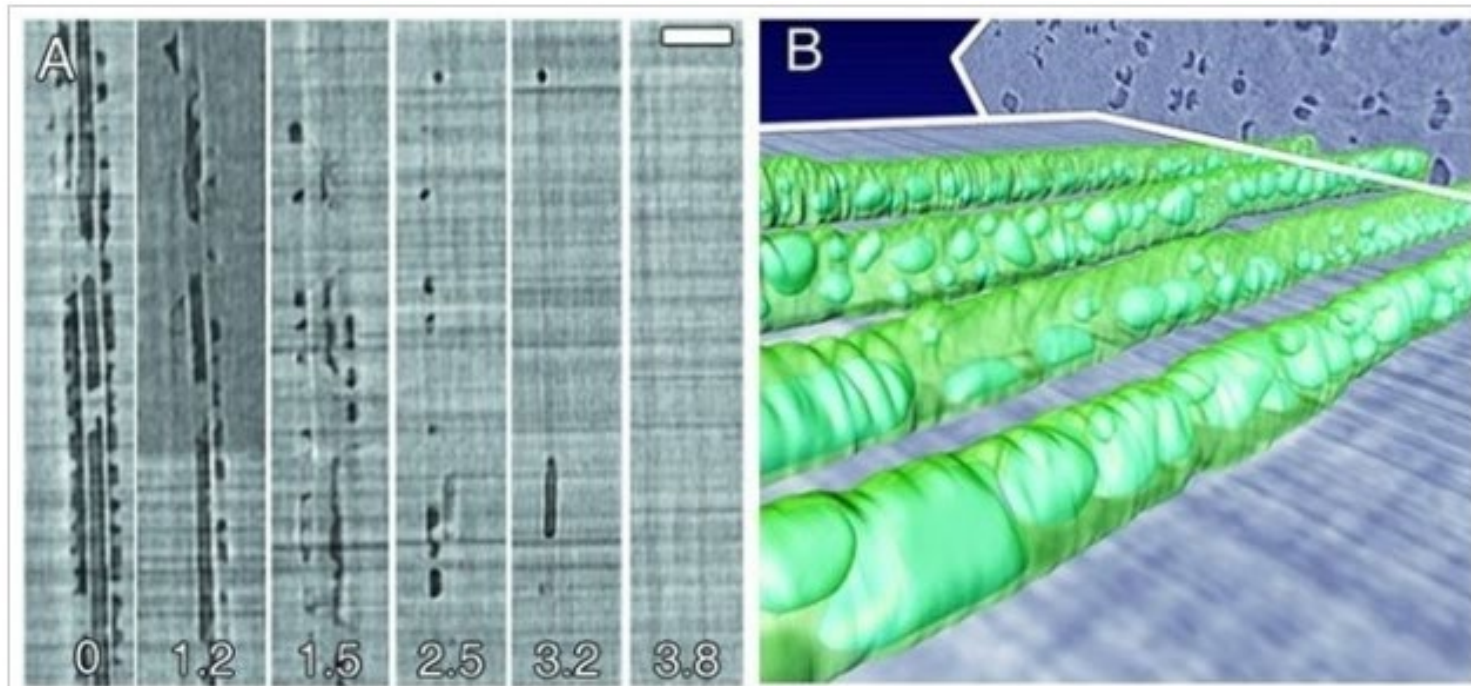


Figure 9: Air seeding mechanism.

Demonstrates how increasing tension in a functional water filled vessel eventually reaches a threshold where an air seed is pulled across a pit membrane from an embolized conduit. Air is seeded into the functional conduit only after the threshold pressure is reached.

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Embolism Repair



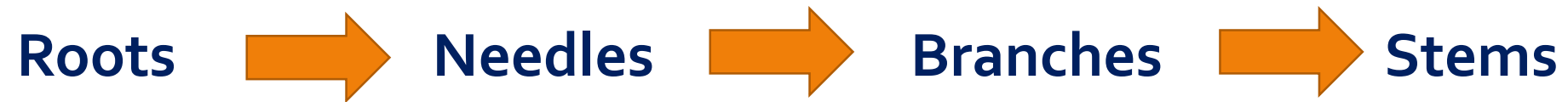
- Ray parenchyma
- Aquaporins

Figure 10: Embolism repair documented in grapevines (*Vitis vinifera* L.) with X-ray micro-CT at the ALS facility at Lawrence Berkeley National Lab CA, USA.

(A) Longitudinal section showing a time series of cavitated vessels refilling in less than 4 hrs; (B) 3D reconstruction of four vessel lumen with water droplets forming on the vessel walls and growing over time to completely fill the embolized conduit.

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Vulnerability to embolism

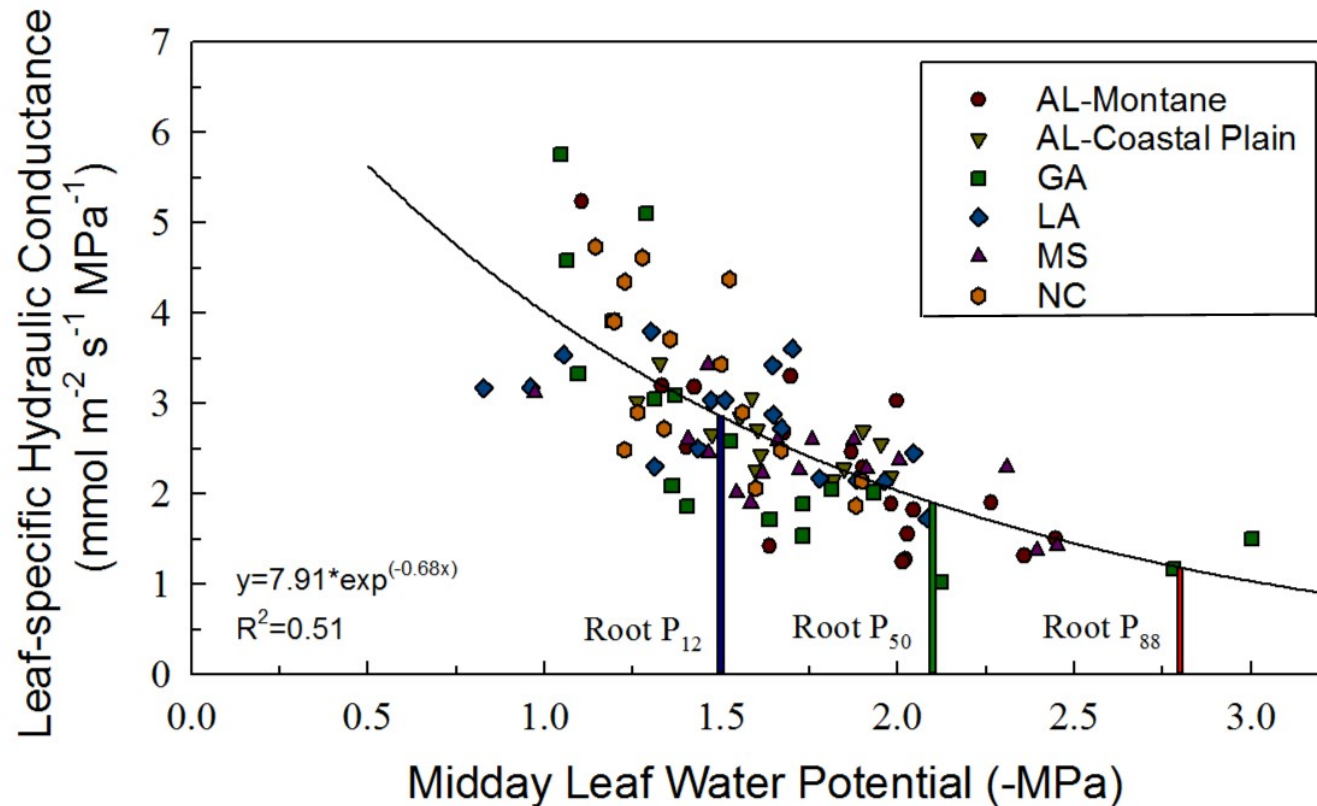


Embolism Resistance in Pines

- Studies of other southern pines (mostly mature trees) indicate moderate embolism resistance.
- Longleaf pine seedlings appear to be in the group of more embolism resistant pines, meaning they can tolerate lower water potentials (more water stress) before reaching 50% loss of conductivity.
- No direct species comparisons at the seedling stage on the same site.

Seedling Hydraulic Conductance

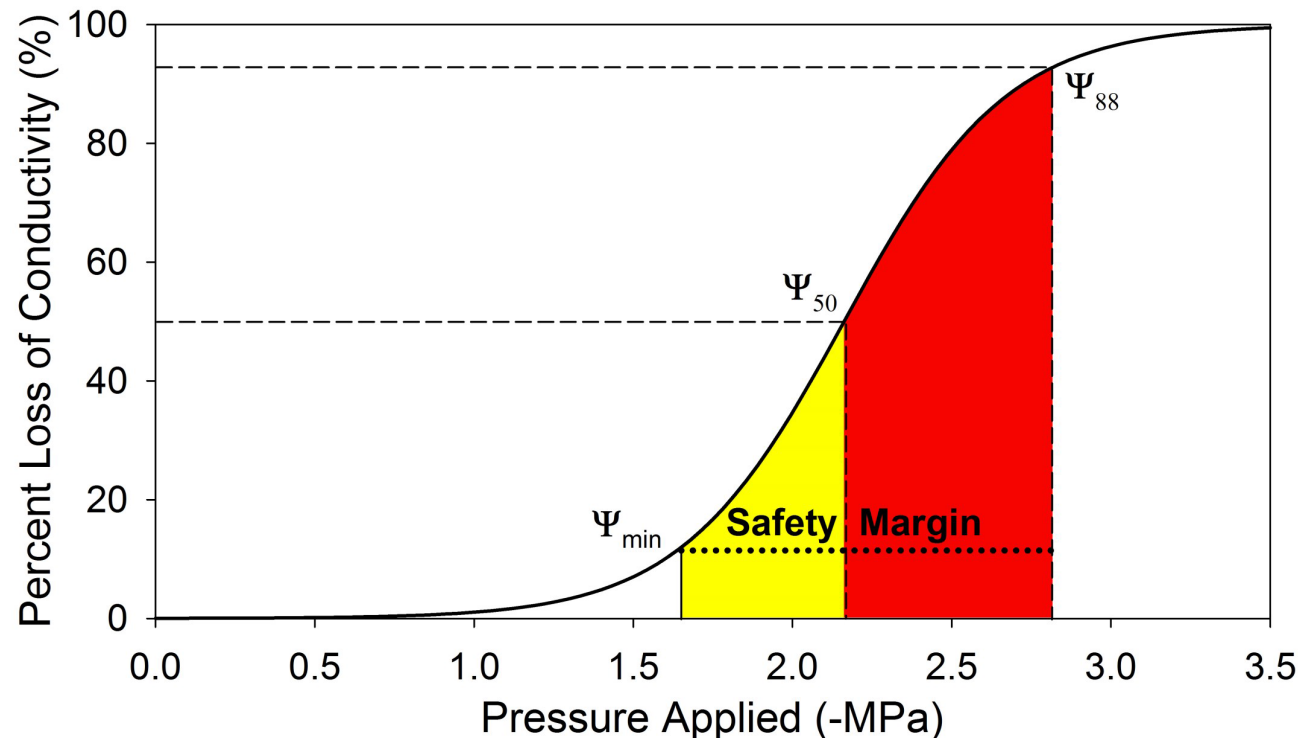
- Measure of how efficiently water is transported through the seedling as water stress increases



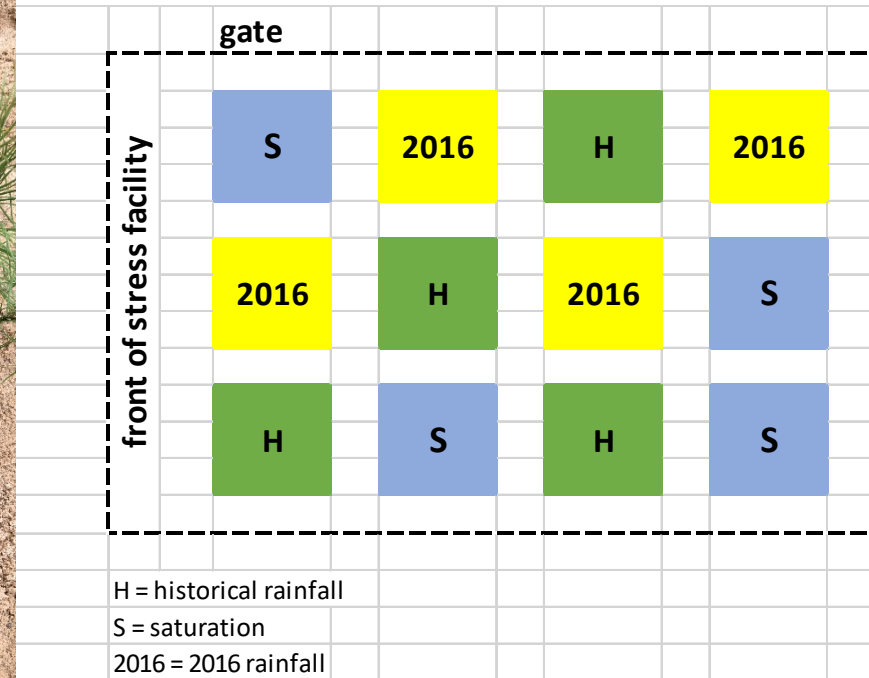
- Average leaf-specific hydraulic conductance reduced 50% near root P₅₀.
- *Root embolism a significant control on whole plant water transport in longleaf pine seedlings.*

Hydraulic Safety Margins

- Longleaf pine seedlings have a small hydraulic safety margin and high risk of hydraulic failure under extreme drought, as shown for other *Pinus* species.
- Little within species plasticity in hydraulic architecture and integrated traits such as P_{50} , as shown for other pines.

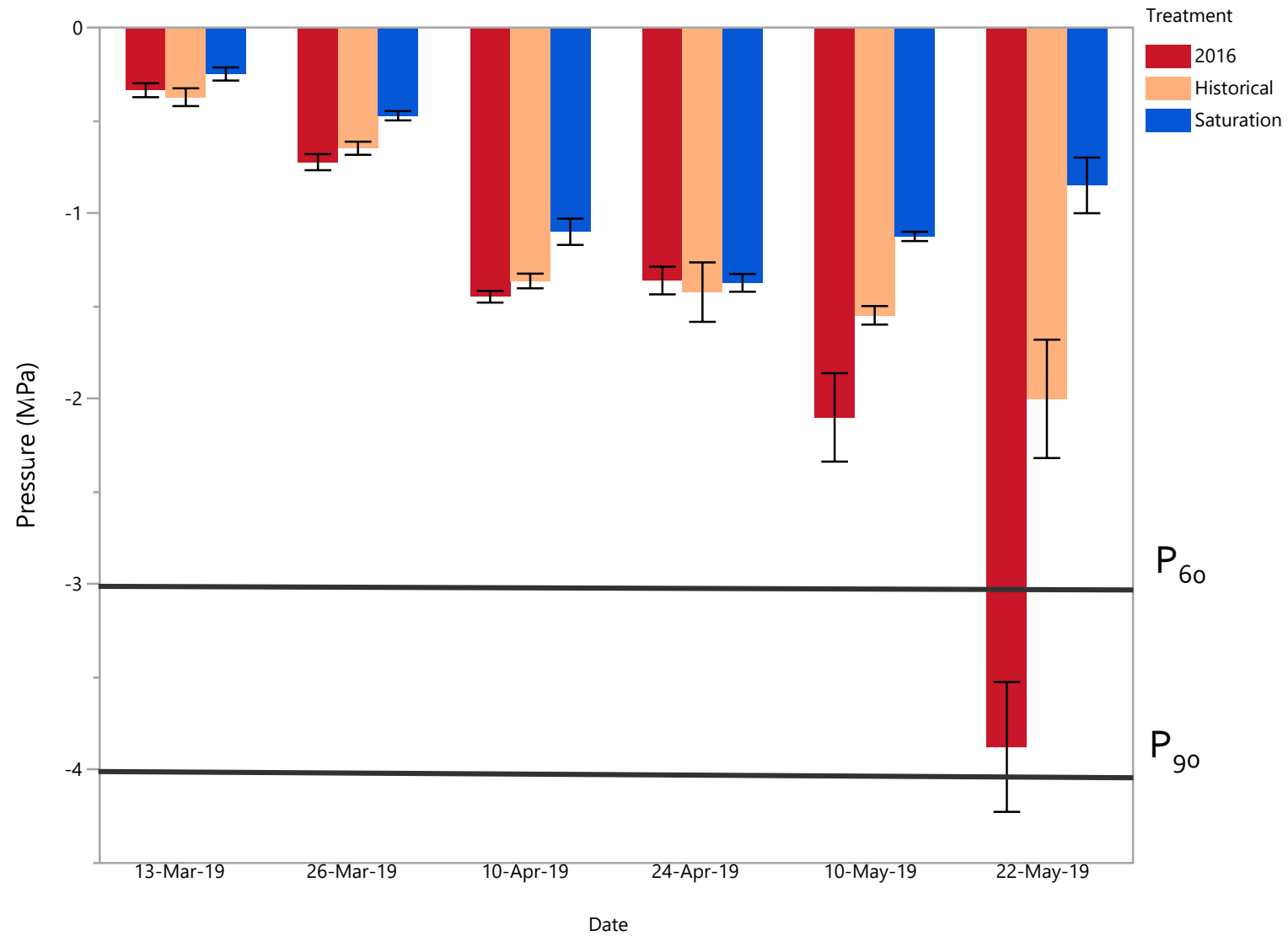


Trial Design

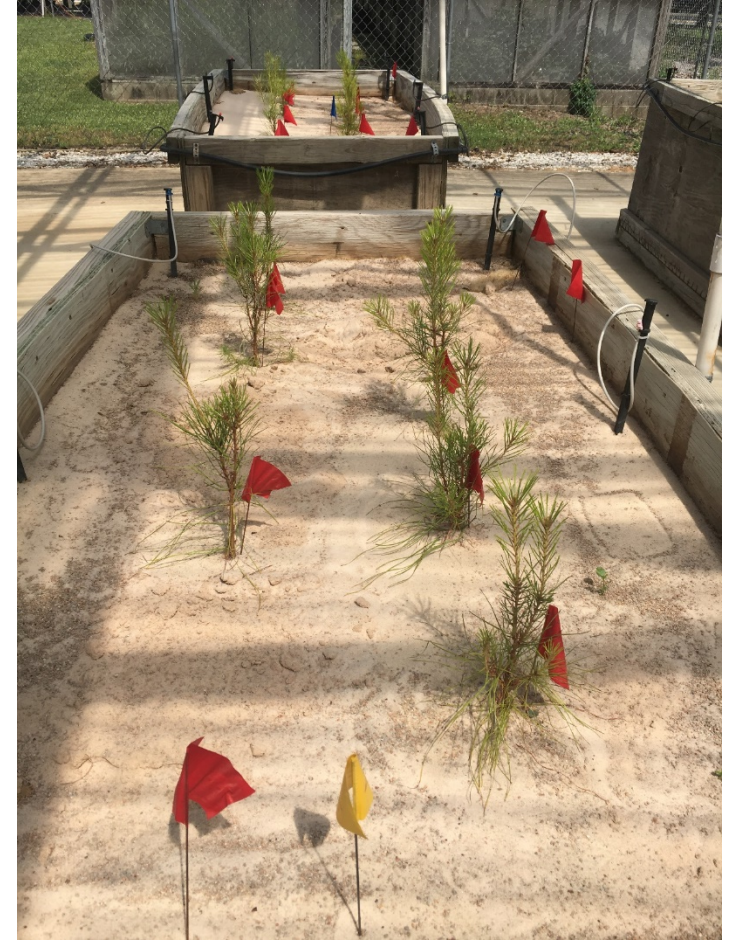
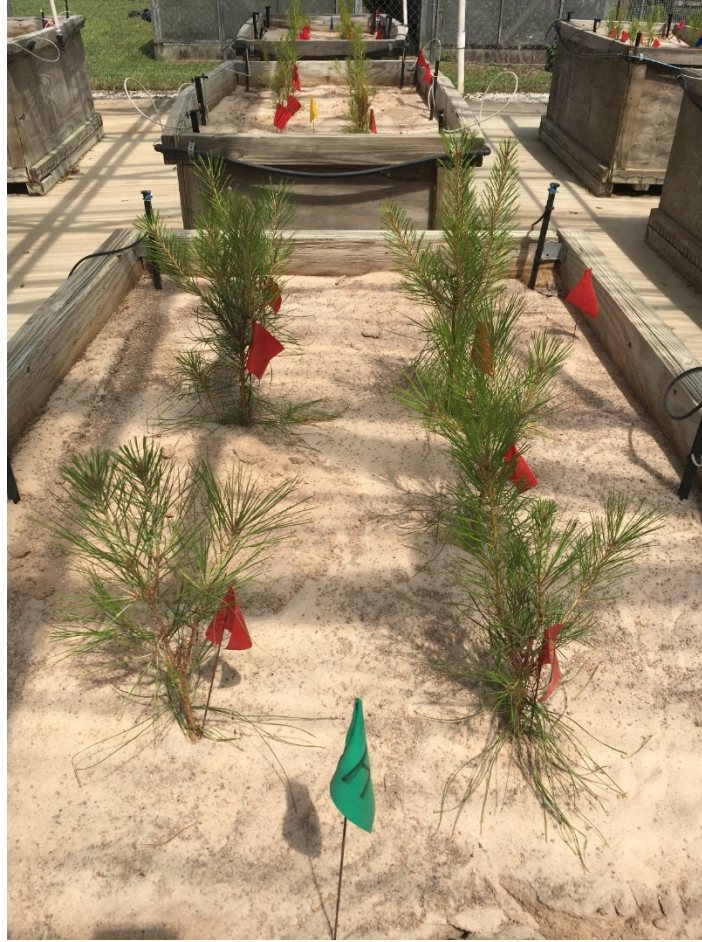


Historical Rainfall 16.38 mL per seedling per week

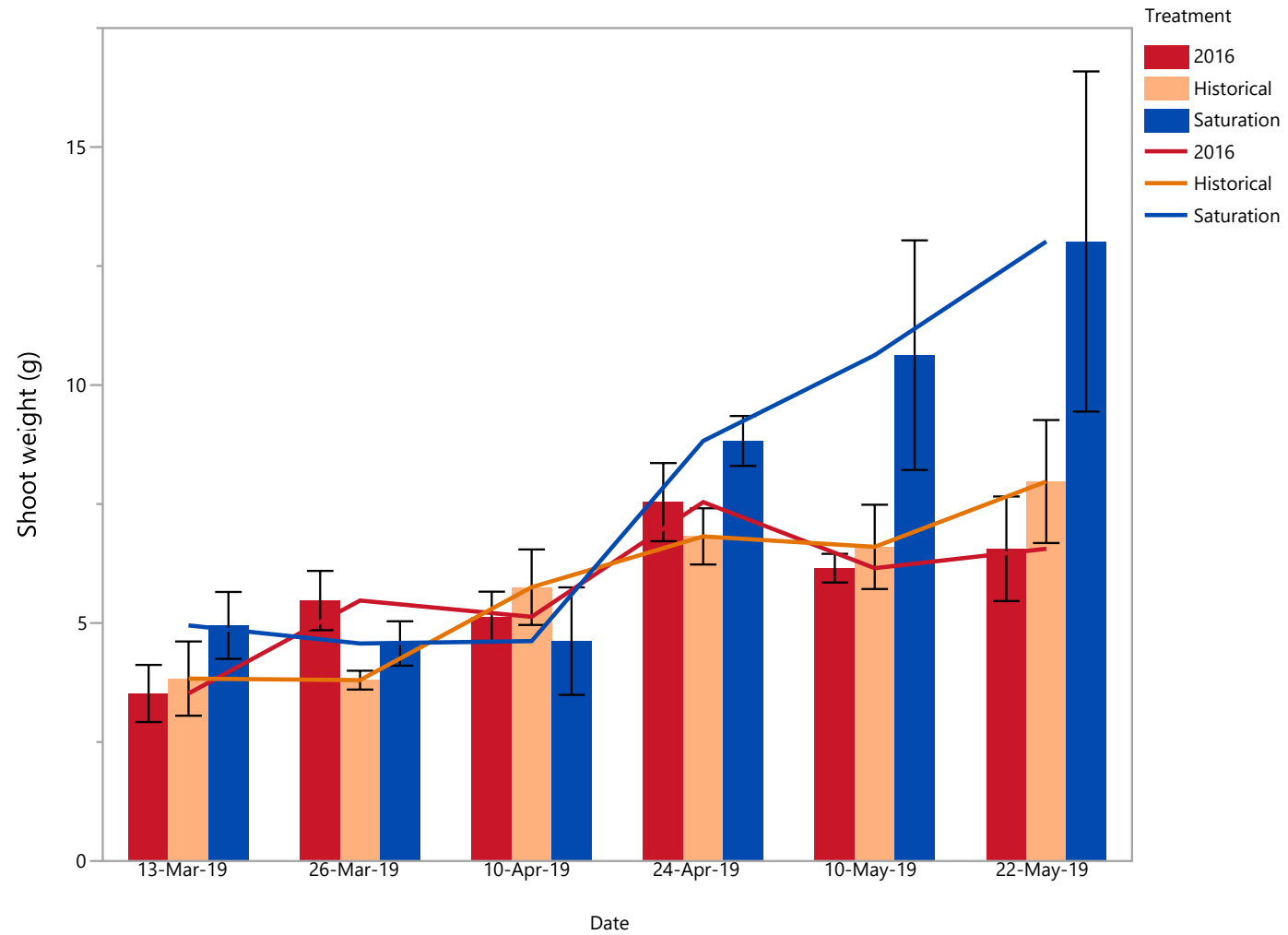
Results – Midday Water Potential



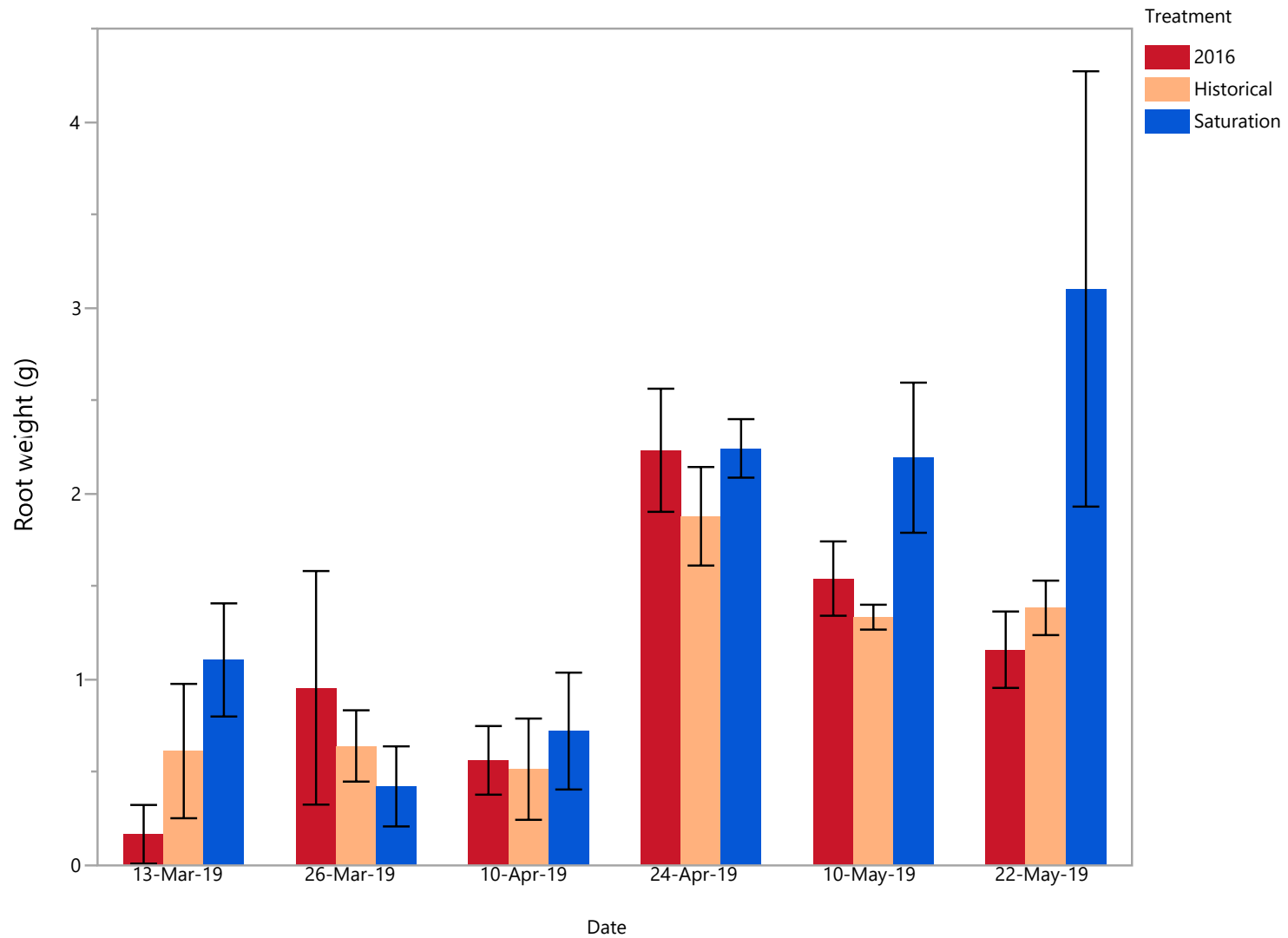
Results



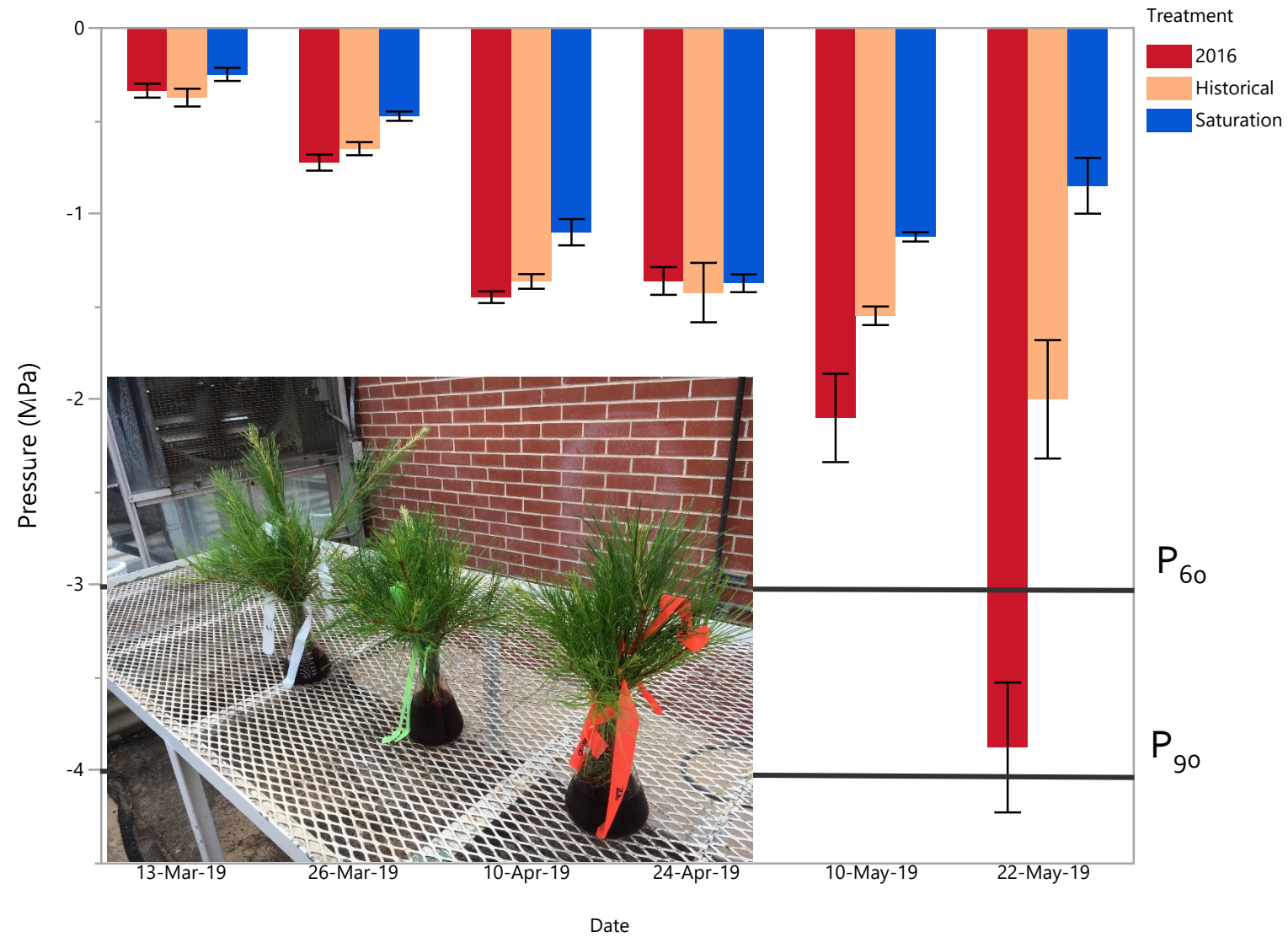
Results – Shoot Weight



Results – Root Weight



Results – Midday Water Potential



Applications

- Root health and root hydraulic conductivity is important to outplanting success.
- Embolized roots will increase drought vulnerability of outplanted seedlings.

