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U.S. DEPARTMENT OF AGRICULTURE

Rocky Mountain Research Station

Science You Can Use *(in 5 minutes)*

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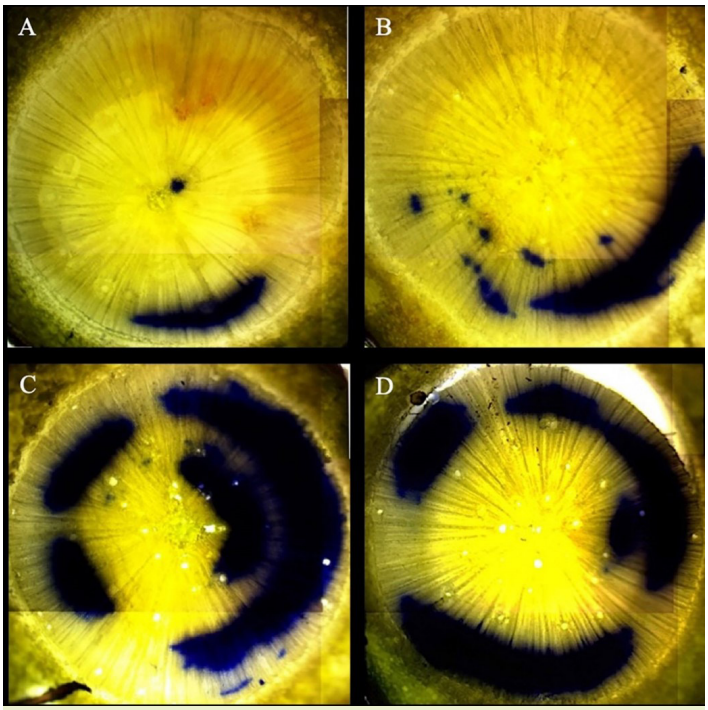
Drought Conditioning: Improving Environmental Resilience and Outplanting Success with Nursery-Grown Ponderosa Pine Seedlings

Climate change poses challenges to ecological restoration and reforestation work, particularly in arid parts of the western United States. To incorporate future drought scenarios in the management of National Forests and Grasslands, scientists are working closely with plant nurseries to develop cultivation strategies that support plant adaptation in water-limited environments. Researchers are interested in overcoming physiological and morphological limitations to improve outplanting survival rates.



Cross-sectioning of blue stained xylem structures in nursery-grown ponderosa pine across high to low irrigation levels and simulated drought. The stained areas are used to visualize fluid conductivity in the xylem. Photograph by Dr. Owen Burney.

A.) High nursery irrigation level and Control simulated drought treatments. B.) High nursery irrigation level and Drought simulated drought treatments. C.) Low nursery irrigation level and Control simulated drought treatments. D.) Low nursery irrigation level and Drought simulated drought treatments.

When mature, ponderosa pine is known for its drought-resistant characteristics and thus managers prefer planting these seedlings after disturbances such as wildfire and pest outbreaks. However, young ponderosa survival rates can be low after planting. Only one-quarter of nursery-grown ponderosa pine seedlings are expected to survive when planted on disturbed sites in the southwestern United States. Nursery conditioning may be able to improve the establishment success of ponderosa pines planted for forest recovery.

The National Center for Reforestation, Nurseries, and Genetic Resources (RNGR) operates through the USDA Forest Service's Rocky Mountain Research Station. The center provides guidance and support for the propagation of hardy and resilient plant stock that is better adapted to a growing list of environmental challenges, including heat stress, disease, human-caused disturbance, wildfire, and drought. Dr. Jeremiah Pinto is a Research Plant Physiologist working with RNGR to provide recommendations for nurseries interested in cultivating more resilient restoration tree seedlings across the United States.

In a recent study, Pinto looked at whether limiting irrigation rates would improve drought conditioning in nursery-grown ponderosa pine. Drought conditioning can influence the seedling's wood structure and vascular function to help it withstand extreme

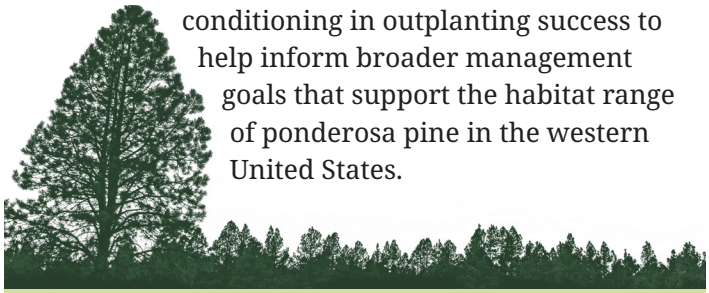
drought. Plants manage against hydraulic failure in water-limited environments by acclimating their morphology and physiologic processes in response to these external conditions. Conditioning at the nursery level creates opportunities for nurseries to help increase young plant survival in drought-prone outplanting sites.

Pinto and his research team used three different ponderosa pine seed sources, under three irrigation conditioning treatments, to determine the impacts of limiting water on plant physiology and morphology, beginning at an early ontological stage of ponderosa pine development. Four weeks after germination, ponderosa seedlings begin to differentiate their xylem. By initiating conditioning treatments between development stages and throughout the first year of a seedling's growth, the research team hypothesized that the plant's capacity to tolerate moisture-limited outplanting conditions would improve.

Seed sources were selected from different regions to determine if consistent results from the conditioning treatments would be observed. The researchers found that exposing ponderosa seedlings to low irrigation levels before outplanting in simulated drought conditions encouraged drought-resistant physiological traits. These traits included higher rates of photosynthesis and greater water-use efficiency in the xylem, compared to the unconditioned seedlings.

When placed in a simulated dry outplanting environment, seedlings conditioned to lower irrigation levels saw greater stem and total dry masses as well as greater percent active xylem areas compared to unconditioned controls. The seed sources used in this experiment did not experience major variations in plant physiology across the study, which suggests that there is a broader application for these conditioning techniques across a wide range of seed sources.

These findings support using drought conditioning to improve the resiliency of outplanted ponderosa seedlings. Pinto and others are continuing to expand the research on the role of nursery conditioning in outplanting success to help inform broader management goals that support the habitat range of ponderosa pine in the western United States.



KEY MANAGEMENT CONSIDERATIONS

- Given the high rates of seedling mortality in reforestation projects, drought conditioning may help increase establishment rates of ponderosa pine outplantings in drier sites.
- Drought conditioning of nursery-grown ponderosa pine seedlings encourages morphological and physiological changes that bolster rates of plant growth and hydraulic activity of seedlings that are placed in simulated dry outplanting environments.
- Physiological and morphological changes were fairly independent of the seed sources used in this experiment, suggesting that conditioning treatments may be broadly applied across a wide array of seed sources.

FURTHER READING

Davis, A.S.; Pinto, J.R. 2021. The scientific basis of the target plant concept: An overview. 12(9): 1293.

Pinto, J.R.; Sloan, J.L.; Ervan, G.; Burney, O.T. 2023. Physiological and morphological responses of Pinus ponderosa seedlings to moisture limitations in the nursery and their implications for restoration. Frontiers in Plant Science. 14: 1127656.

Rocky Mountain Research Station. 2022. Hitting the target plant: Guiding principles for post-disturbance reforestation in a changing climate. Science You Can Use. Bulletin 55.

PROJECT LEAD

Jeremiah Pinto was a Research Plant Physiologist based at the National Center for Reforestation, Nurseries, and Genetic Resources (RNGR). His primary research focused on improving plant nursery practices and investigating the role of experimental treatments on plant morphology and physiology. His work is part of a growing effort to improve outplanting resiliency and reestablishment success for restoration work across the United States.