Assisted Migration: A Viable Silvicultural Technique for Facilitating Adaptation of Northern Forest Tree Species to a Warmer and Drier Future World?

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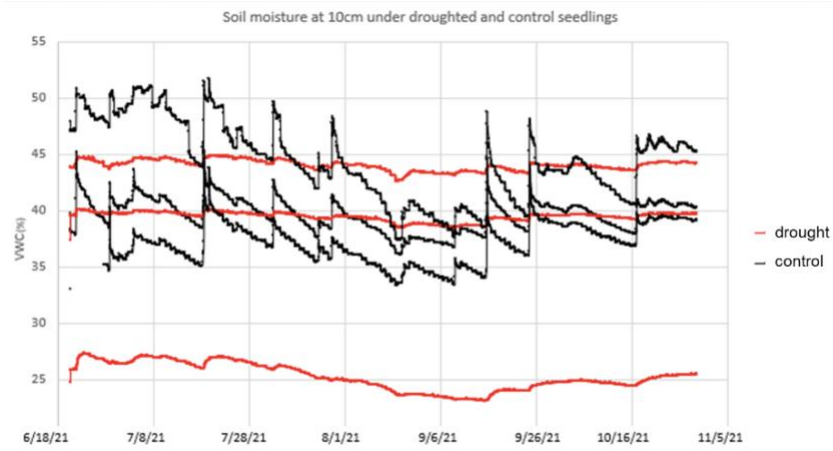
Project abstract

NSRC researchers and local stakeholders in the four-state region will evaluate the capacity of ten assisted migration tree species to acclimate to new environments and drought in a periodically drier, warmer future Northern Forest. Researchers will conduct a drought experiment to assess seedling acclimation potential and trait plasticity. Measurements will be collected at six other six sites to evaluate seedling responses across broader temperature and precipitation gradients at the landscape scale. The results will inform guidelines for selecting suitable assisted migration species as part of climate change adaptation strategies to promote future resilient forests. See a New Hampshire Bulletin article about the project.

Progress 2021

In summer 2021, we established a precipitation manipulation experiment within the Adaptive Silviculture for Climate Change (ASCC) project at Second College Grant, NH. We located our study sites in 1-acre gaps that were harvested and planted in 2019 with future-adapted seedlings. We identified 130 healthy individuals representing eight species across three experimental blocks. Half of the seedlings were outfitted with 1.5m^2 rainfall exclusion shelters. Soil moisture sensors (n=18) were installed under a representative subset of shelters and adjacent to control seedlings to determine whether the shelters were successful at drying down the soils to physiologically significant levels. Soil moisture content (%VWC) was monitored from June-November and showed that most shelters eliminated the spikes in VWC seen in control sensors following rain events. However, VWC never reached levels low enough to induce drought stress in the seedlings (Figure). Researchers identified several factors that potentially contributed to the consistently high soil moisture beneath the drought shelters. Soil moisture data from 2020 led us to believe that relatively low transpiration in the 1-acre gaps resulted in soils that were too wet to dry out with our rainfall exclusion shelters. Since there was no demonstrated drought effect (based on soil moisture data and visual observation of seedlings), the rainfall exclusion shelters were removed at the end of the growing season to prevent any further disturbance to the ongoing ASCC experiment.



Data from soil moisture sensors installed under rainfall exclusion shelters and control seedlings

Problems or changes

Although the rainfall exclusion shelters were effective at diverting rainfall off the single-seedling subplots, they did not lead to a significant decline in soil moisture relative to the control subplots. During fall-winter 2021-22, we convened several meetings with the full research team (PIs and Cooperators) to explore possibilities for improving the design of the rainfall exclusion shelters in the second project year.

However, after extensive discussion, the research team concluded that no acceptable design option existed that met our two key criteria for success: (1) a high probably of inducing a drought, and 2) not causing excessive disturbance that could compromise the ASCC experiment. Finally, the team decided to conduct a controlled common garden experiment at UNH with a similar set of assisted migration seedlings. Several advantages were identified with this approach, including: (1) improved ability to successfully induce a drought and maintain soil moisture within predetermined ranges; (2) improved uniformity of growing conditions aside from the soil moisture treatments; (3) protection from herbivory (which limited our choice of seedlings in the field study); and (4) sample replication allowing for destructive sampling for both the ecophysiological processes and functional trait measurements, as well as quantification of above- and below-ground biomass allocation at the end of the study. This approach will contribute valuable knowledge about the suitability of various species and ecotypes as candidates for assisted migration in the Northern Forest, especially in terms of adaptation to drought. When combined with the results from the ASCC experiment, results will help inform silvicultural recommendations for assisted migration practices. Finally, this approach will have broader impacts for developing guidelines for forestry-related research using drought experiments to assess tree seedlings' potential in assisted migration or other planting techniques.

This experimental drought subplot shows obstacles (aggressive vegetation, coarse woody debris, rocks, steep topography, and pre-existing research projects) encountered when building rainfall exclusion shelters.

Plans for 2022

To assess the viability of assisted migration in our region and fulfill the project goals, we will conduct a controlled covered common garden experiment from spring 2022 to fall 2024 adjacent to the University of New Hampshire's MacFarlane Greenhouse. Seedlings from seven timber species were purchased locally (New Hampshire) and from climate analogues representing warmer and drier climates (Virginia and Michigan respectively). Once acclimated, seedlings will be divided into control, moderate drought (MD) and severe drought (SD) treatments. Control seedlings will be maintained between field capacity and -1MPa soil water potential. In the CMD, seedlings will be maintained at a soil water potential around -2MPa for the duration of the growing season; a moisture level representative of moderate drought in our region based on local data. In the SDRW treatment, water will be withheld until the seedlings reach their wilting point and then kept between field capacity and -1MPa soil water potential for the remainder of the growing season. In the second year, both drought treatment groups will receive a complete soil dry-down treatment to identify the physiological and environmental thresholds at which mortality occurs. In conjunction with this experiment and as a reference, a subset of seedlings will be planted in a forest gap recently created at West Foss Farm (also in Durham, NH). These field-grown seedlings will provide additional information on the suitability of our study seedlings to successfully establish in a field setting, including under ambient climate, soil freezing, snowpack, and herbivory conditions.

Collaboration with USFS

The USFS has increasing interest in planting trees as a climate change adaptation strategy. We collaborate with two USFS personnel who have experience with precipitation manipulation experiments and tree planting—Cameron McIntire and Christopher Woodall, respectively. They serve on the advisory committee for this project and have been aiding in decision-making and interpretation of results.