Foliar Water Uptake in Urban Broadleaf Trees

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Introduction

- **Purpose:** City trees have access to far fewer nutrients and are exposed to more pollutants than their forest counterparts. Their root systems are also buried under concrete, making water difficult to extract from the ground. This study explores a potential adaptation mechanism of these trees: water can be absorbed through leaves through a process known as **foliar water uptake (FWU)**.
- FWU has been observed in extreme environments such as in tall, fog-absorbing redwood trees[1] and in dryland juniper plants[2], but this is the first time it is being evaluated in an urban environment.

Acer rubrum (Red Maple) *Quercus rubra* (Red Oak)

Methods

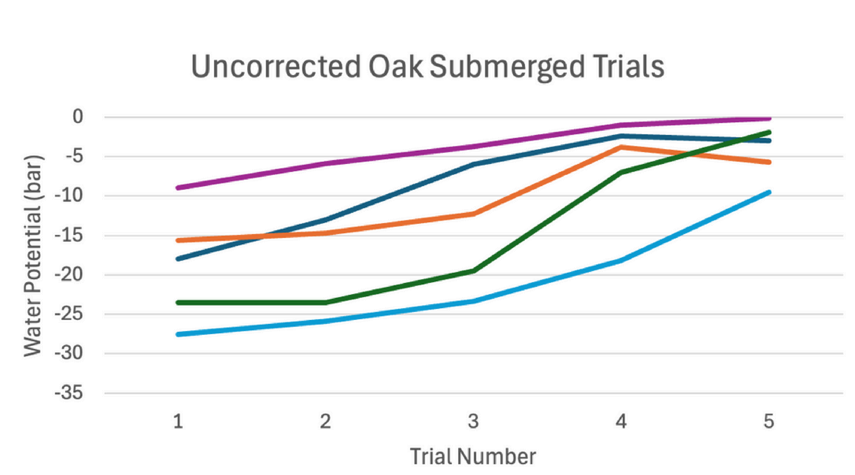
- **Leaf water potential** measurements were used to assess FWU and determine the level of water stress.
  - Leaf water potential is measured using a Scholander pressure bomb – an instrument that applies pressure to a chamber.
    - We inserted an excised leaf into the pressure bomb and applied pressure until the tip of the leaf's petiole became wet.
  - Less negative water potentials indicate a greater quantity of water within the leaf.
- We sampled red maple trees and red oak trees from around Boston University in the morning and afternoon.

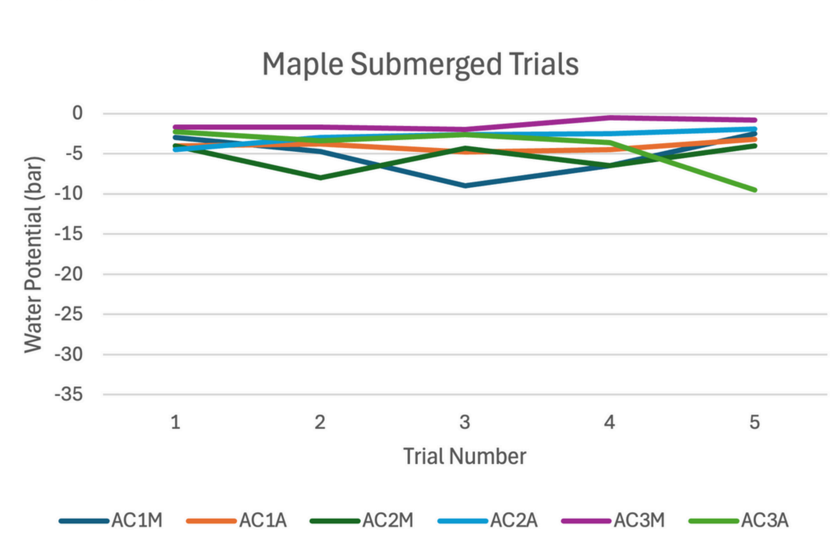
Water potential was measured for a beginning control, 3 treatment groups and a final control:

Control Start	Mist Top	Mist Both	Submerge	Control End
Dry leaves measured at beginning of experiment.	Leaves misted with 4 mL of water applied to top of leaves.	Leaves misted with 4 mL of water applied to the top and 2 mL applied to bottom of leaves.	Leaves submerged in water for ~75 minutes.	Dry leaves measured at end of experiment.

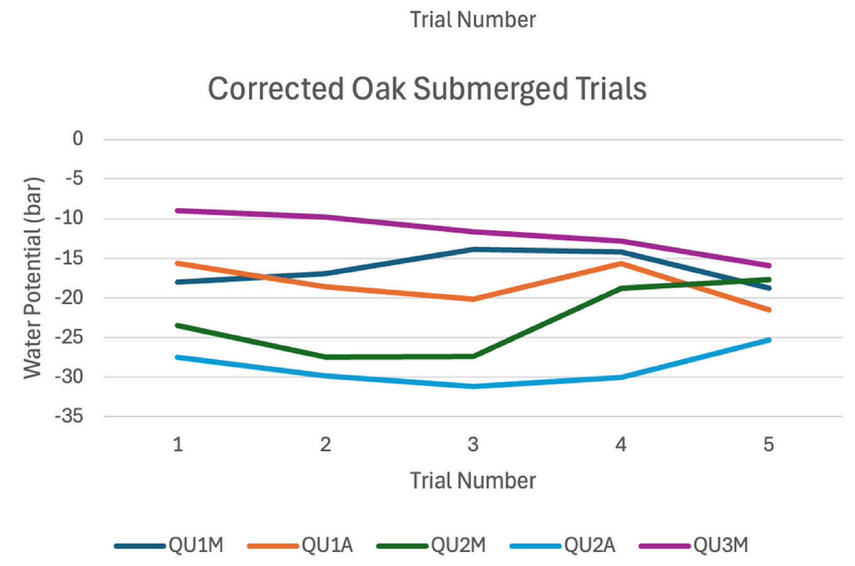
Corrections

Submerged oak leaf trials showed a trend with time, suggesting that branches were taking up water through lacerations created by cutting prior leaves. Using the slope of the overall linear trend, we adjusted our data to correct for this trend.



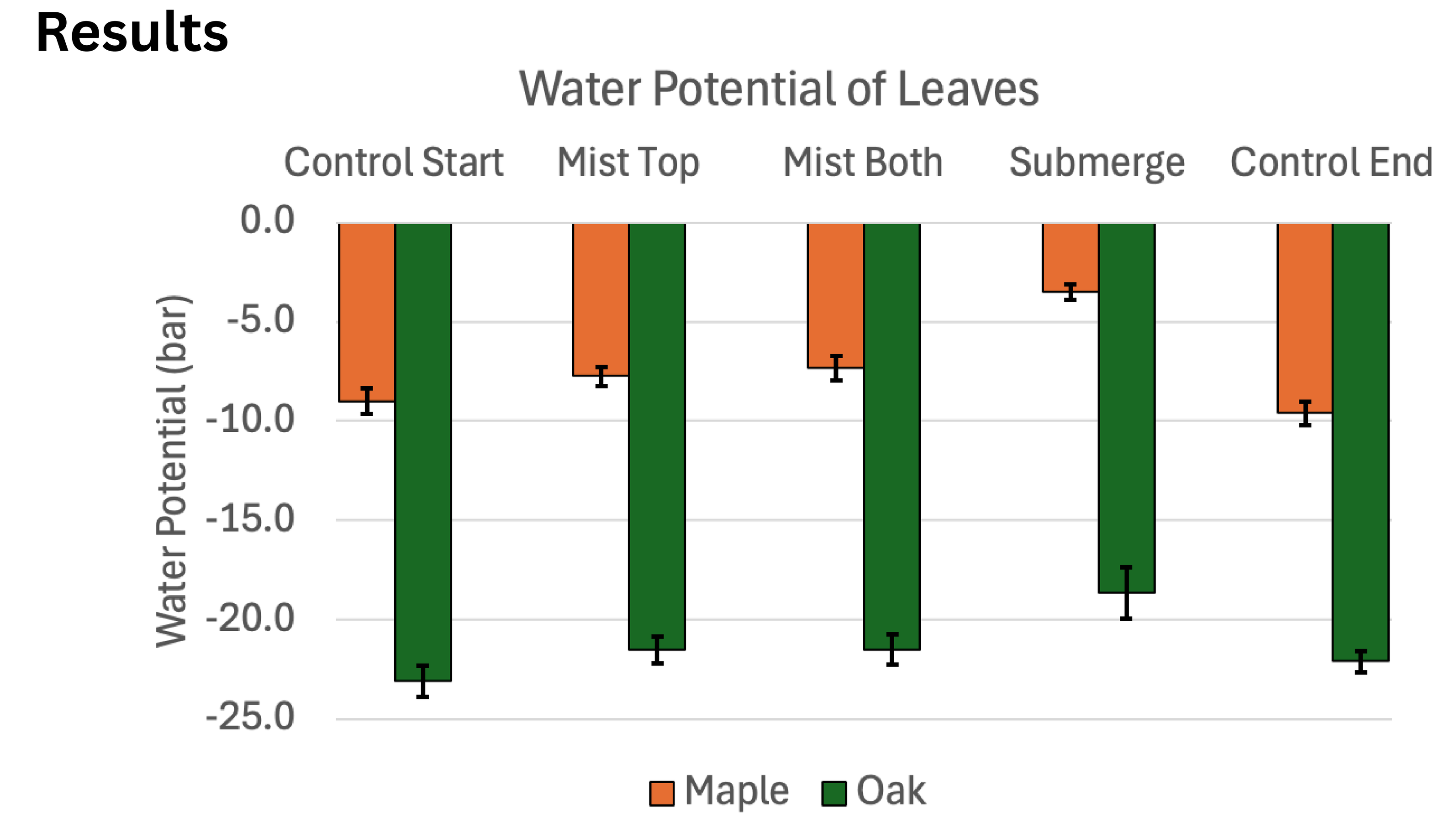


No linear trend

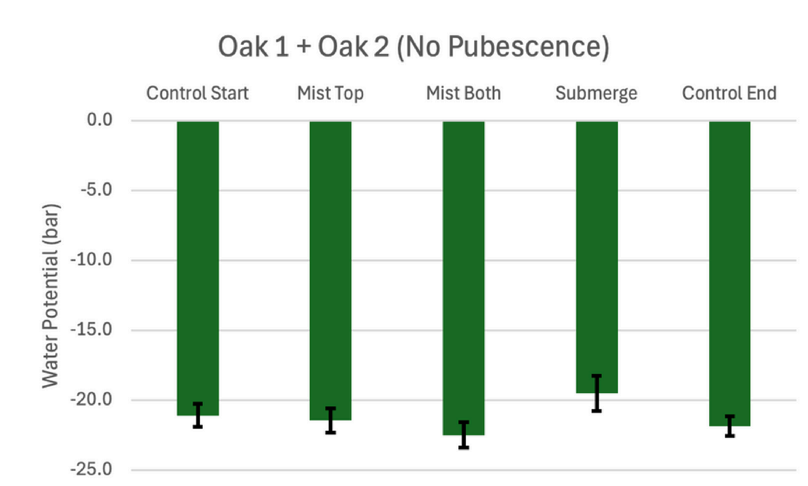


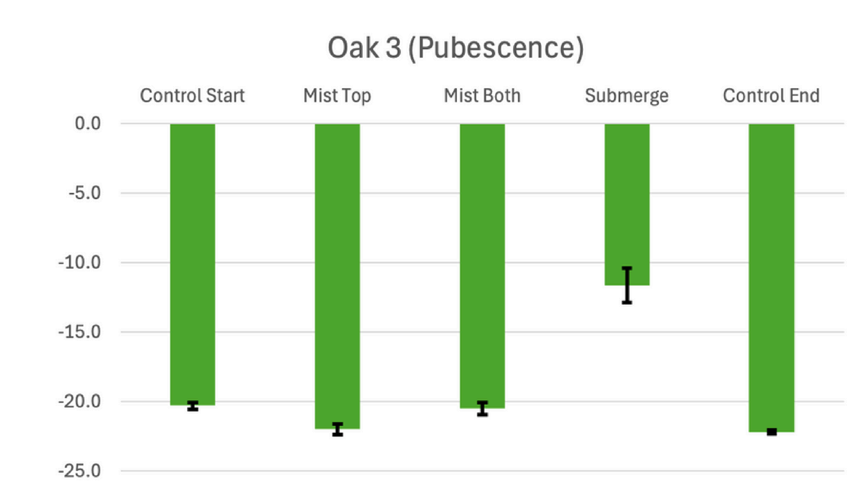
Linear trend and correction

Results



- Negative water potential values reflect the degree of tension within the plant's vascular system.
- Maple leaves took up water in both mist and submersion trials. There was a 13.8% change in Mist Top, a 18.3% change in Mist Both, and a 61.1% change in Submerge compared with controls.
- In oak leaves, more negative water potential values were seen overall, but oak leaves did not take up a significant amount of water: Only a 7% change was observed in both misting trials. The submersion trials had a 37.9% change, but the data only reflected significant uptake in **two** trial groups.





- For the oak submersion samples where uptake was observed, foliar pubescence was present. Additional measurements are required to establish a causal relationship.

Discussion

- We observed that urban broadleaf trees, especially maples, are able to absorb water through their leaves. Species-level differences were observed in the overall capacity to take up water. This is potentially due to structural differences between genera; oaks have thicker cuticles and ring-porous vascular structure, while maples have diffuse-porous vascular structure.
- We hypothesize that leaf size and petiole length could be related to water potential and uptake rates. No significant relationship was found with the leaf petiole length, but area evaluation is still in progress.
- It is likely that antecedent weather conditions, soil moisture, and the time of measurements influenced our results, but that analysis is not yet complete.
- Plant pubescence refers to small hairs on the surface of the leaf that are intended to regulate water loss, protect from herbivores, and regulate temperature. However, we found that leaves with pubescence also absorbed significantly more water than leaves without it. Further research is needed to confirm this relationship.
- The ability of trees to absorb water through their leaves could provide an important source of water in city environments that are dominated by concrete surfaces, and could potentially explain why city trees are able to flourish despite high stress.
  - City planning could also improve based on the ability of these trees to deal with urban stresses: maple leaves can absorb water better and could be more beneficial to cities than oaks.

References

1. Dawson, T. E. Fog in the California Redwood Forest: Ecosystem Inputs and Use by Plants. Oecologia 1998, 117 (4), 476–485. https://doi.org/10.1007/s004420050683.
2. Breshears, D. D.; McDowell, N. G.; Goddard, K. L.; Dayem, K. E.; Martens, S. N.; Meyer, C. W.; Brown, K. M. FOLIAR ABSORPTION of INTERCEPTED RAINFALL IMPROVES WOODY PLANT WATER STATUS MOST during DROUGHT. Ecology 2008, 89 (1), 41–47. https://doi.org/10.1890/07-0437.1.

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