Water isotopologues reveal versatile plant water sourcing strategies in a highly altered urban landscape

Erica Almance[1], Suprina Shrestha[1], Ricardo Sánchez-Murillo[1] & Brooke Best[2]

1. Tracer Hydrology Group, Department of Earth and Environmental Sciences, University of Texas at Arlington, Arlington, TX, USA; 2. Fort Worth Botanic Garden and Botanical Research Institute of Texas, Fort Worth, TX, USA

I. Research Questions

Plants and the Urban Water Cycle

- What role do plants play in partitioning the urban water cycle? For example, what soil depths do representative urban tree species uptake water from?
- How does the plants' water sourcing change with seasons?

Centrifugation Method for Water Extraction

- Does the extracted water amount have an impact on isotopic values?

II. Study Site

Fort Worth Botanic Gardens

Palmex (rain) collector

Suction lysimeters used to collect soil water

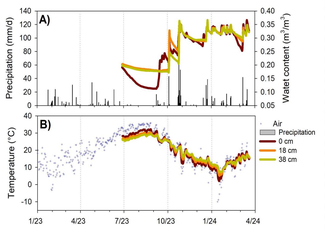


Figure 1: Upper panel shows daily precipitation and soil water content (0, 18, and 38 cm) (2023-2024). Lower panel shows air temperature and soil temperature (0, 18, and 38 cm).

HOBOlink data loggers used to collect soil temperature and soil moisture data.

III. Methods

Weekly throughfall collection → Weekly (lysimeters) and monthly (destructive samples) soil water was collected → Monthly stem and root samples were collected from Boxelder Maple, Cherry Laurel, and Elderberry → **Centrifugation extraction and water isotope analysis**

Event-based precipitation samples: N = 509 (2022-2024)

Throughfall (rainfall reaching the ground through the canopy): N = 37 (2023-2024)

Total soil water samples: N = 161

117 of these were destructive soil samples.

Soil and plant samples were centrifuged at 11,000 rpm, 5 °C, for 1.5 hrs.

Total stem samples: N = 166
Total roots samples: N = 65

IV. Gravimetric Analysis

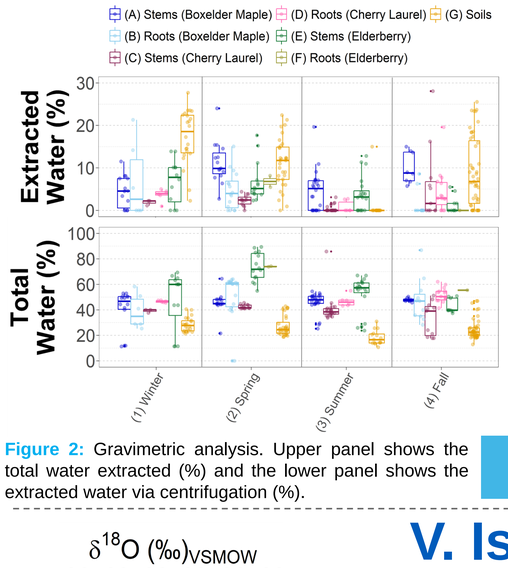


Figure 2: Gravimetric analysis. Upper panel shows the total water extracted (%) and the lower panel shows the extracted water via centrifugation (%).

- **84%** of all soil water samples were analyzed for stable isotopes.
- Water was extracted from **68%** and **55%** of **stem** and **root** samples, respectively.
- Mean **soil, stem, and root water extractions (%)** were **9.73 ± 9.08 (%), 6.98 ± 5.02 (%), and 3.8 ± 4.78 (%),** respectively.
- Mean extracted **soil** water volumes ranged from **100 µL to 10.5 mL.**
- Mean extracted **stem** and **root** water volumes were **50 µL** and **40 µL**, respectively.

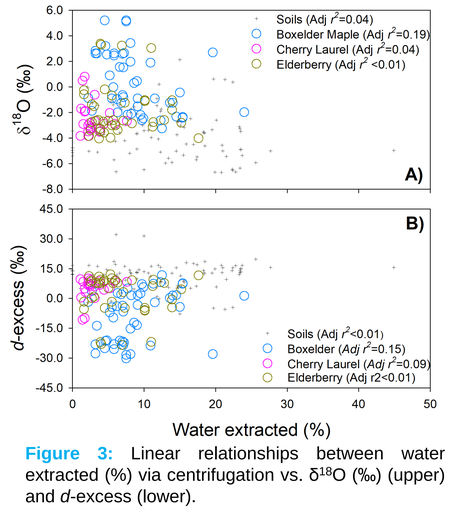


Figure 3: Linear relationships between water extracted (%) via centrifugation vs. $\delta^{18}O$ (‰) (upper) and *d*-excess (lower).

No significant water amount-dependent relationships were detected in the plant (stem and root) and soil isotope values.

V. Isotopic Results

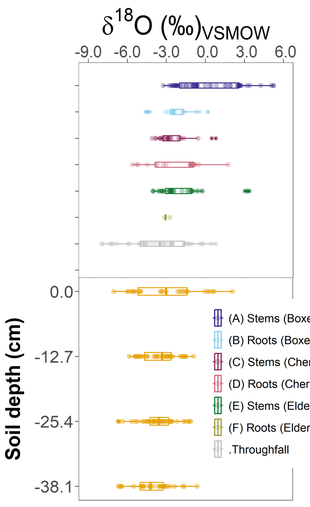


Figure 4: Precipitation, throughfall, stem (xylem), roots, and soil isotopic variability.

Stem $\delta^{18}O$ values exhibited a strong temporal trend from high isotope variability during winter, fall, and summer, with more uniform isotope ratios during the spring season.

Roots exhibited increasingly enriched $\delta^{18}O$ values from winter to summer, becoming depleted again in the fall. Contrary to the stems, roots did not experience depletion in the spring relative to the winter.

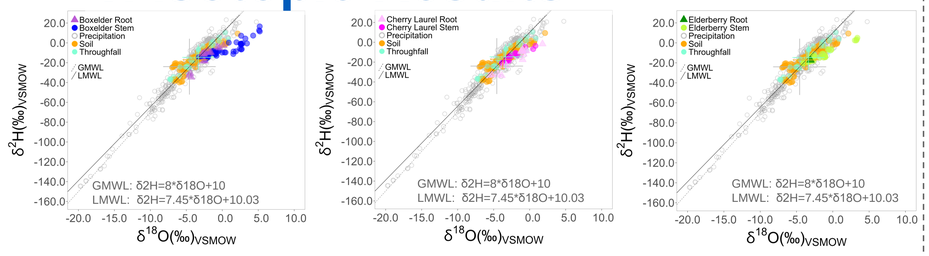


Figure 5: Dual isotope plots showing regional event-based precipitation (2022-2024) (including snow and ice storms), throughfall (2023-2024), soil water (2023-2024), stem (xylem) water (2023-2024), and root water (2023-2024).

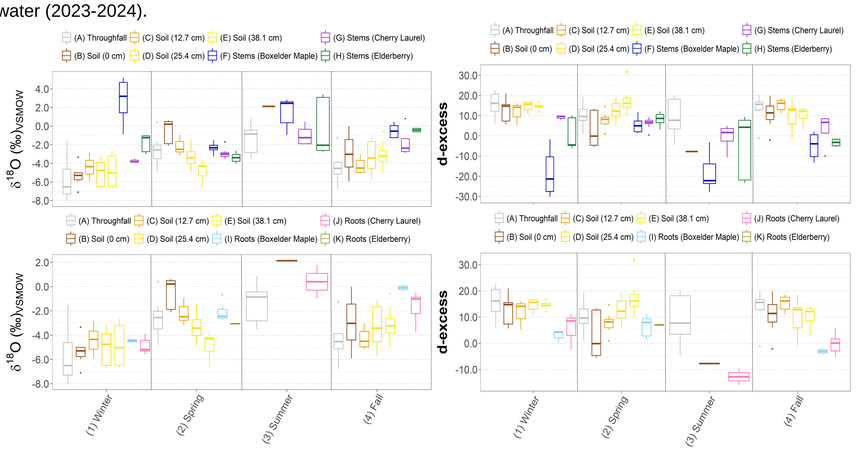
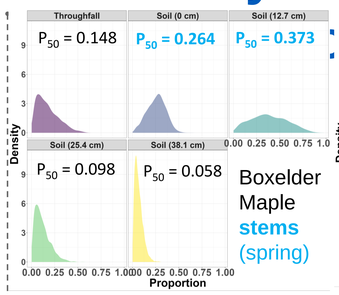
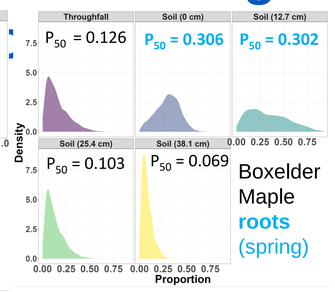


Figure 6: Seasonal isotope variability. Upper left panel: $\delta^{18}O$ (‰) stems, Lower left: $\delta^{18}O$ (‰) roots. Upper right panel: *d*-excess (‰) stems, Lower right: d-excess (‰) roots.

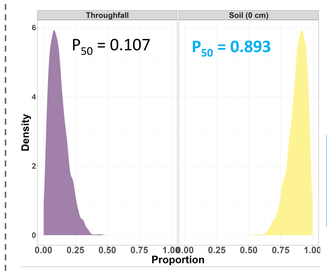
VI. Bayesian Mixing



Boxelder Maple **stems** (spring)



Boxelder Maple **roots** (spring)



Boxelder Maple **stems** (summer)

Figure 7: Density plots resulting from Bayesian mixing analysis of Boxelder Maple. Upper left: spring season. Upper right: spring season. Lower left: summer.

A Bayesian mixing model was used to determine the source contribution (throughfall, soils) to a mixture (xylem and roots).

- **During the spring season (active growing period), the Boxelder Maple (stem and roots) primary water source corresponded with soil depths from 0 to 12.7 cm (5 in).**
- **During the summer season (water-stressed period), the primary water source corresponded with shallower soil moisture from sporadic rainfall events.**

VII. Conclusion

- Our results contribute to **a) the current water extraction method debate for stable isotope analysis (by laser spectroscopy) and b) the understanding of plant water uptake strategies across three representative plant species in an urban green landscape.**

VIII. Future Research

- Water sourcing analysis of multiple individuals of the same tree species in urban areas (Spring and Summer 2024).
- Use sap flow sensors to detect active water transport (Spring and Summer 2024).
- Comparison of isotope ratios obtained from stem and soil samples collected at several times in a continuous 24-hour period.

IX. Acknowledgments

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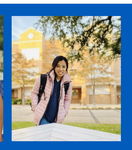

Contact:
Erica.almance@mavs.uta.edu
sxs4148@mavs.uta.edu

Tracer Hydrology Group
Department of Earth and Environmental Science