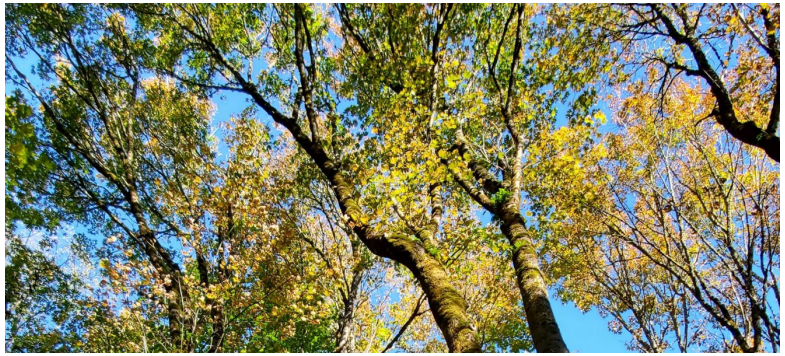
Measuring Individual Tree Water-use in Mature Native Species in the Pacific Northwest to Determine their Benefits for Stormwater Management



Phase II

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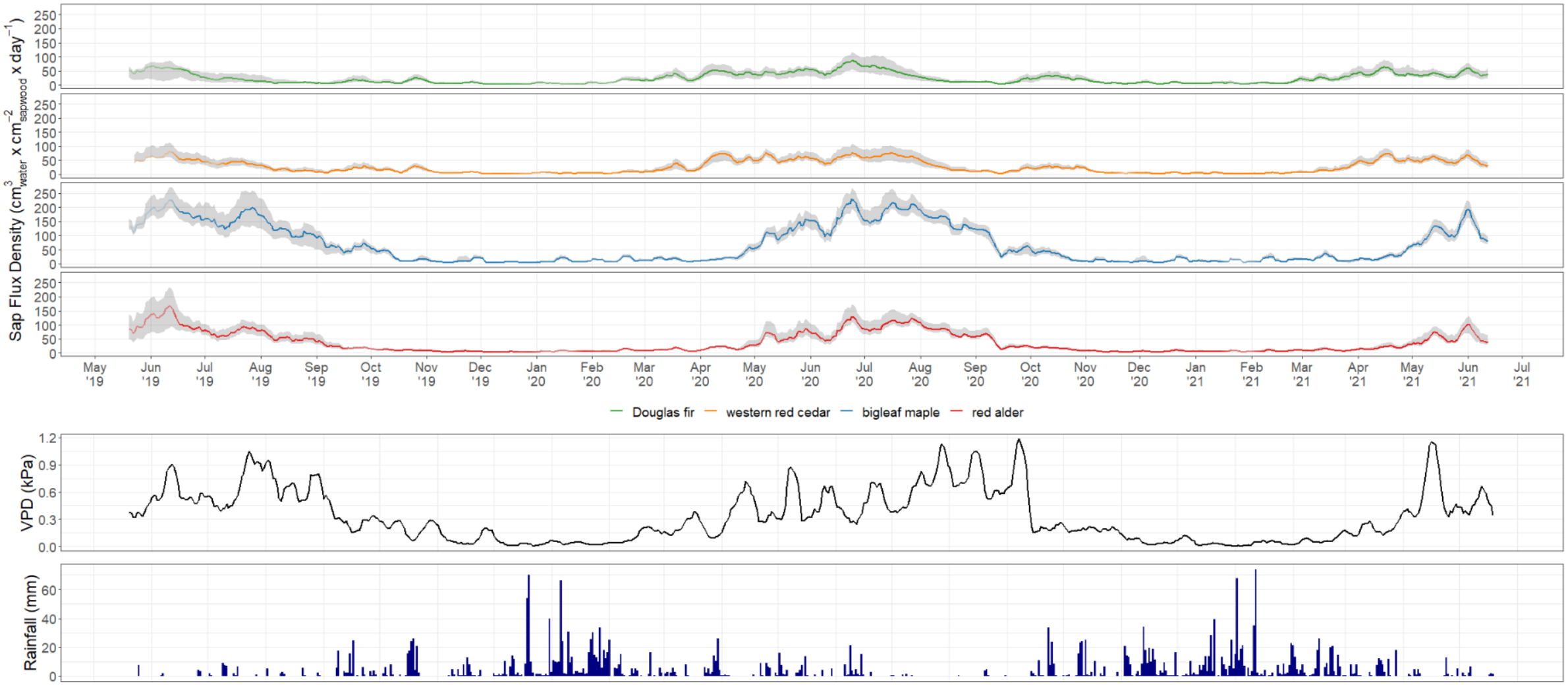
[1]Evergreen State College

[2]Washington State University

[3]Washington Dept. of Natural Resources

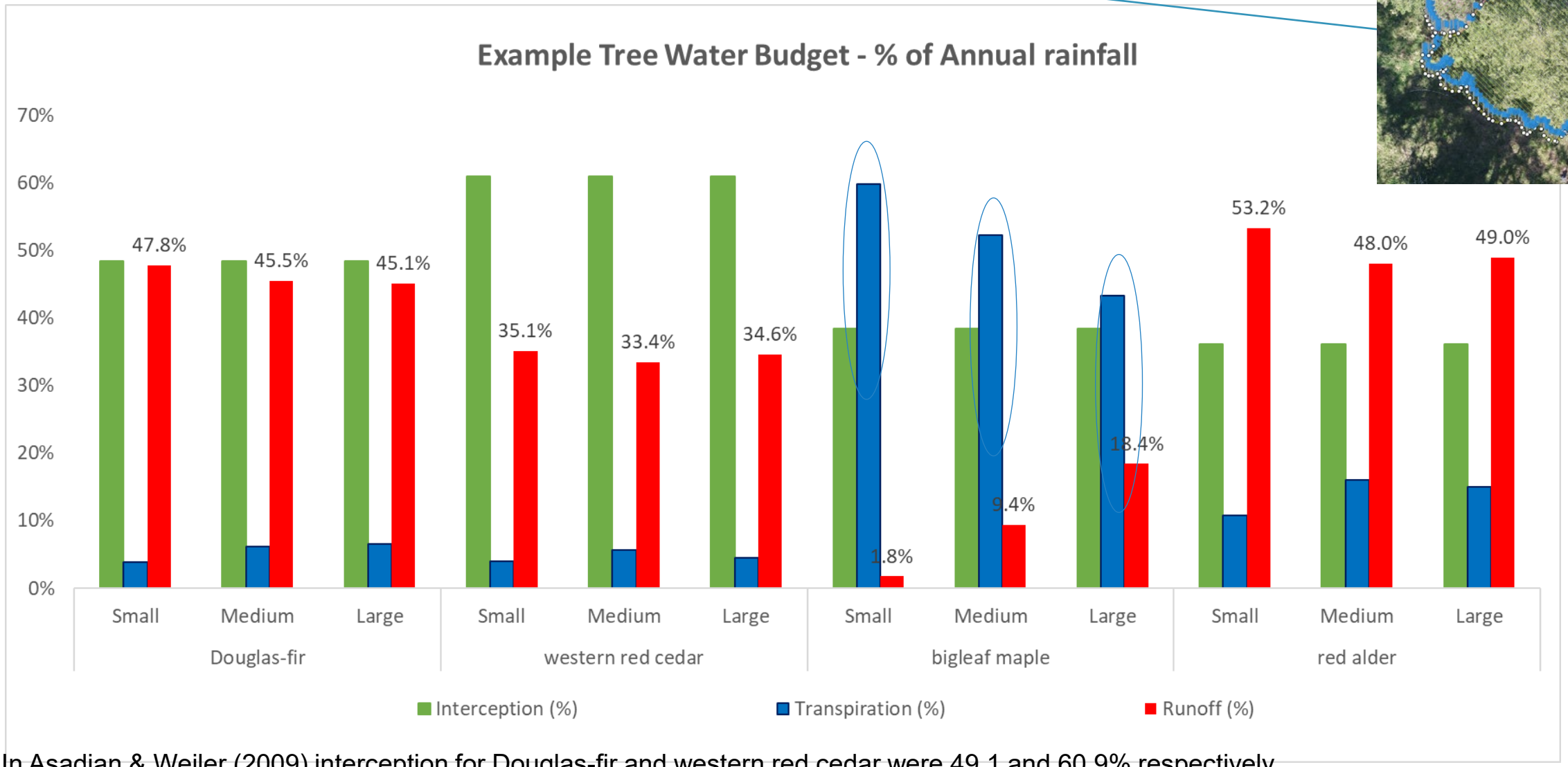
2/12/2025

Transpiration Time Series



Water use for 12 representative trees

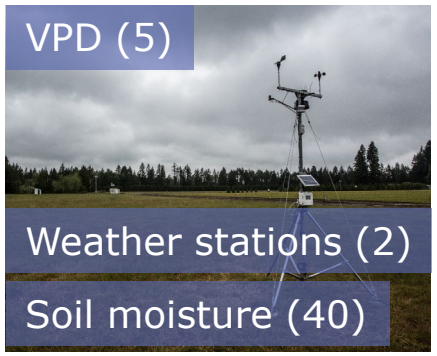
› Normalized by Rainfall Depth over Canopy Area

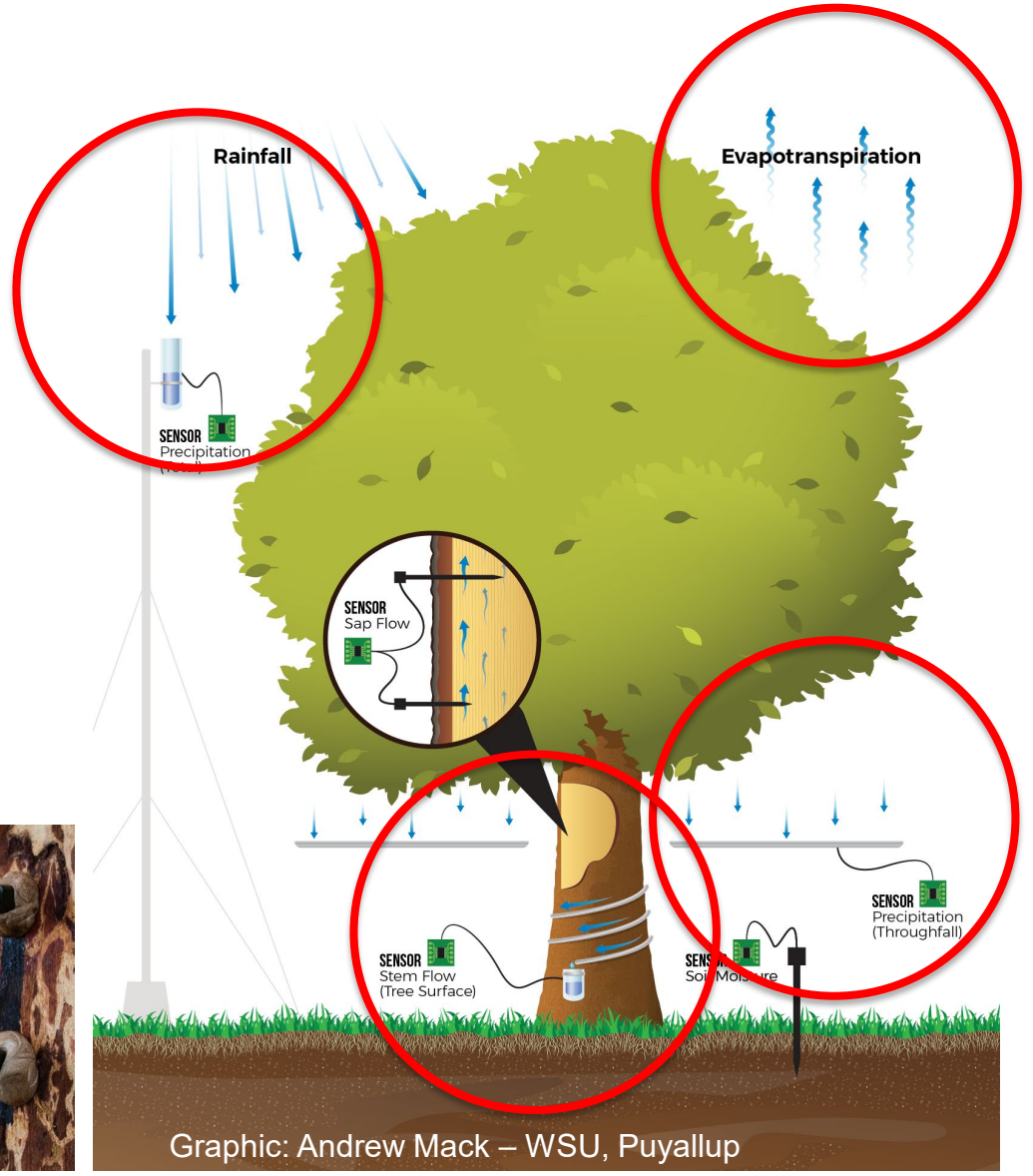


In Asadian & Weiler (2009) interception for Douglas-fir and western red cedar were 49.1 and 60.9% respectively .

Specific project objectives were:

- Establish baseline relationships between **tree size and sap flux** for two of the most common trees in our region: coniferous tree (Douglas-fir) and deciduous tree (Bigleaf Maple).
- Use data representing a **continuation of a multiyear dataset** on annual transpiration rates to ensure quality control
- **Extend sap flux sampling to urban trees** in developed areas using a **mobile sap flux technology** approach.
- Estimate annual canopy interception rates for the same trees

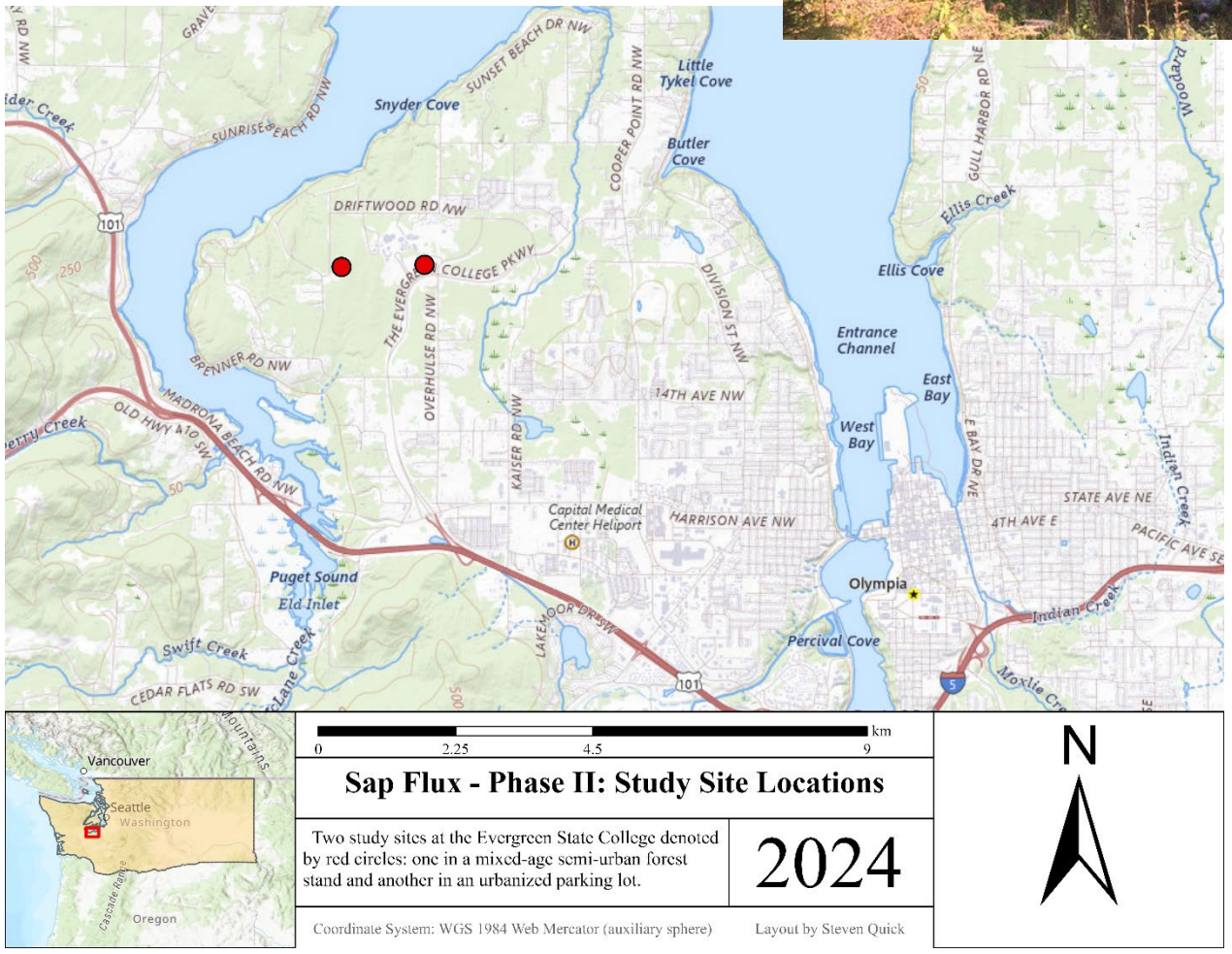




Study Locations

South Puget Sound Region

Figure 3. Representative trees in the PIIE study. Photos taken in Spring 2024.



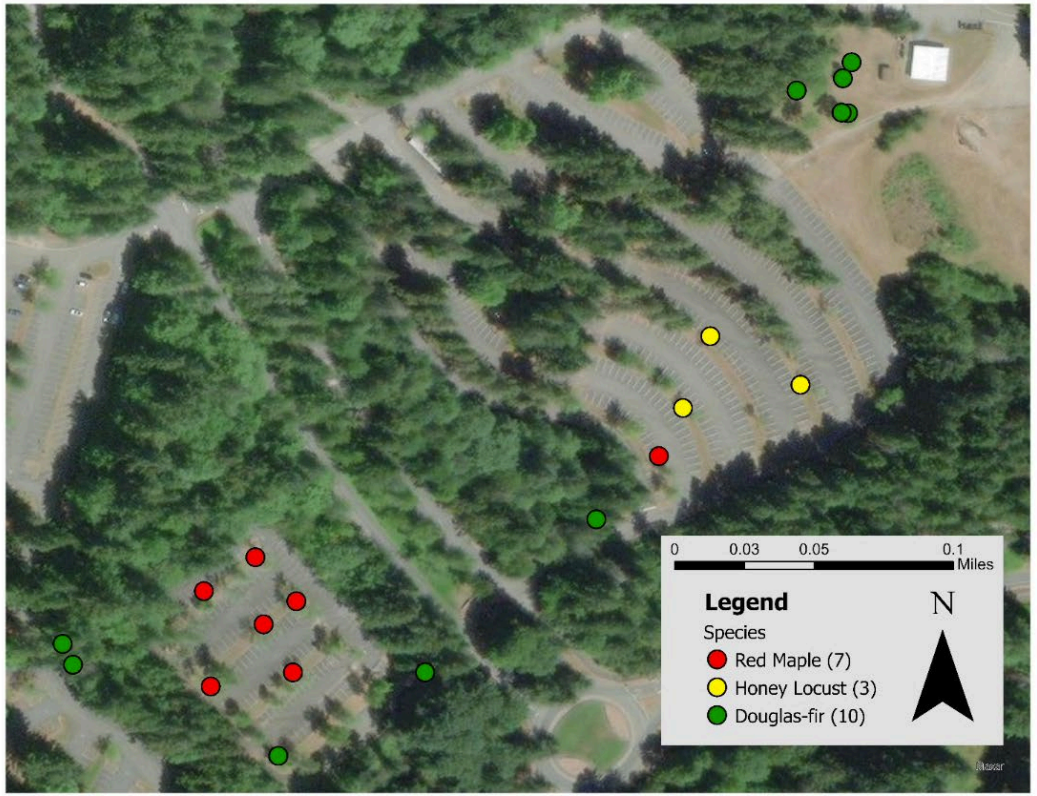


Figure 4. Aerial image of Parking Lot (Plot 3) street tree locations where trees were located for this study.

Methods

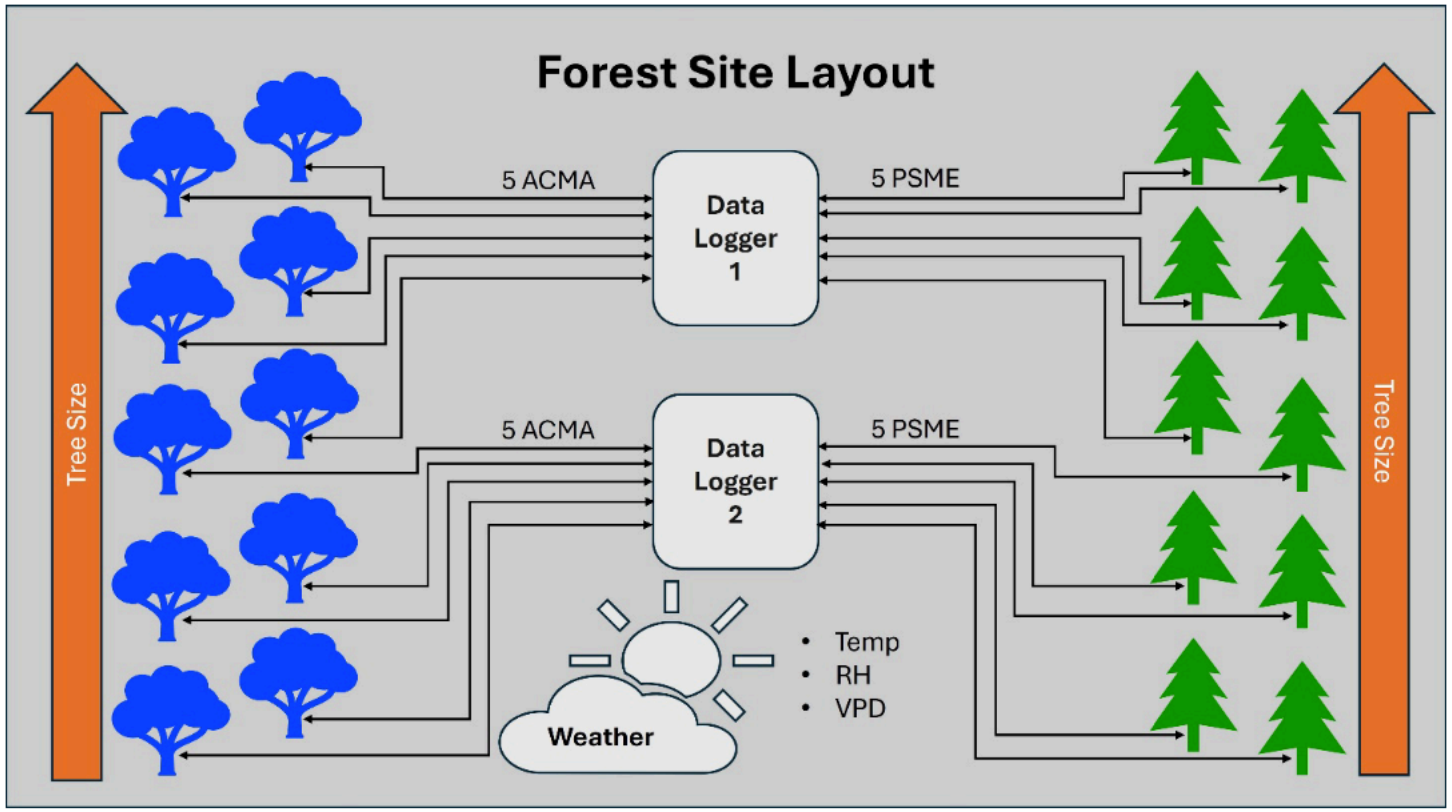


Figure 9. General schematic for fixed- station sampling of forest trees. Trees were selected to represent a gradient in tree sizes. While the diagram depicts maple ACMA (blue) in one direction and PSME (green) in another, the trees were generally interspersed (PSME adjacent to ACMA) at each site, and they are only separated here for schematic clarity.

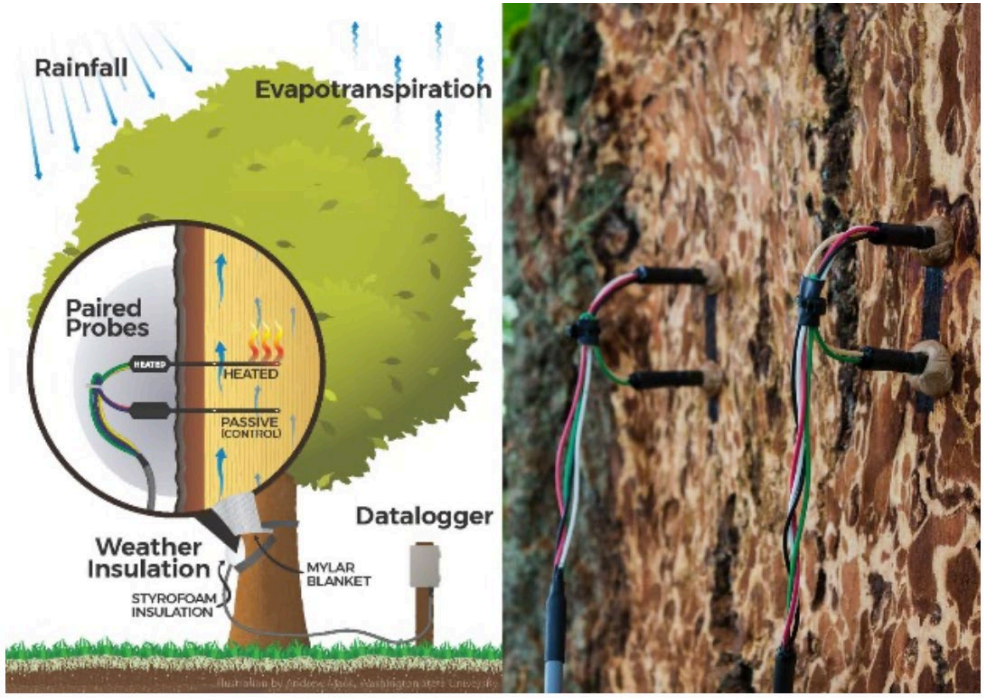
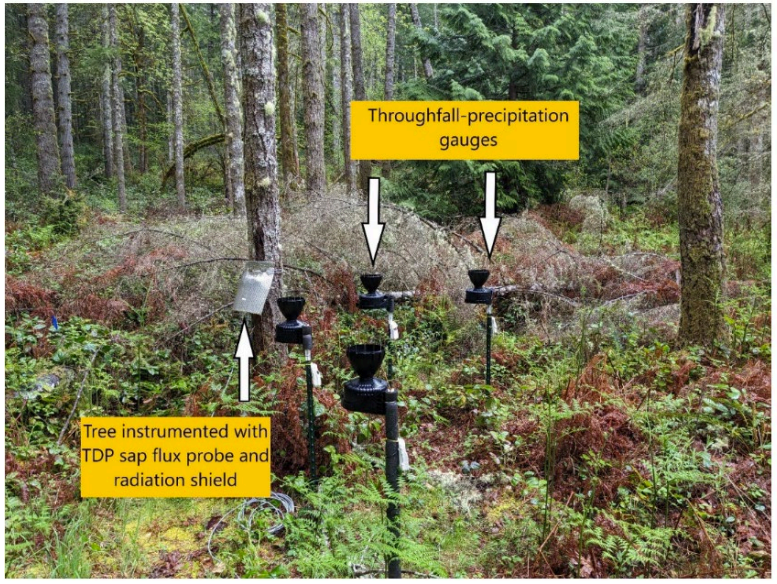


Figure 8. Diagram illustrating the thermal dissipation probe (TDP) method for measuring sap flux (left) in addition to two sets of probes inserted into a Douglas-fir (TDP-50 [left]; TDP-100 [right]) where excess bark has been removed and insulation has yet to be installed.




Trees instrumented with TDP probes and shielded from incidental radiation
Fixed data logger 1
Fixed data logger 2
RX3000 Remote Monitoring Station

Methods

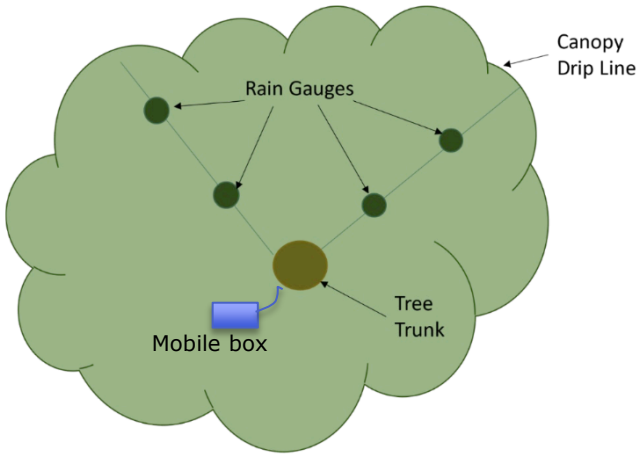
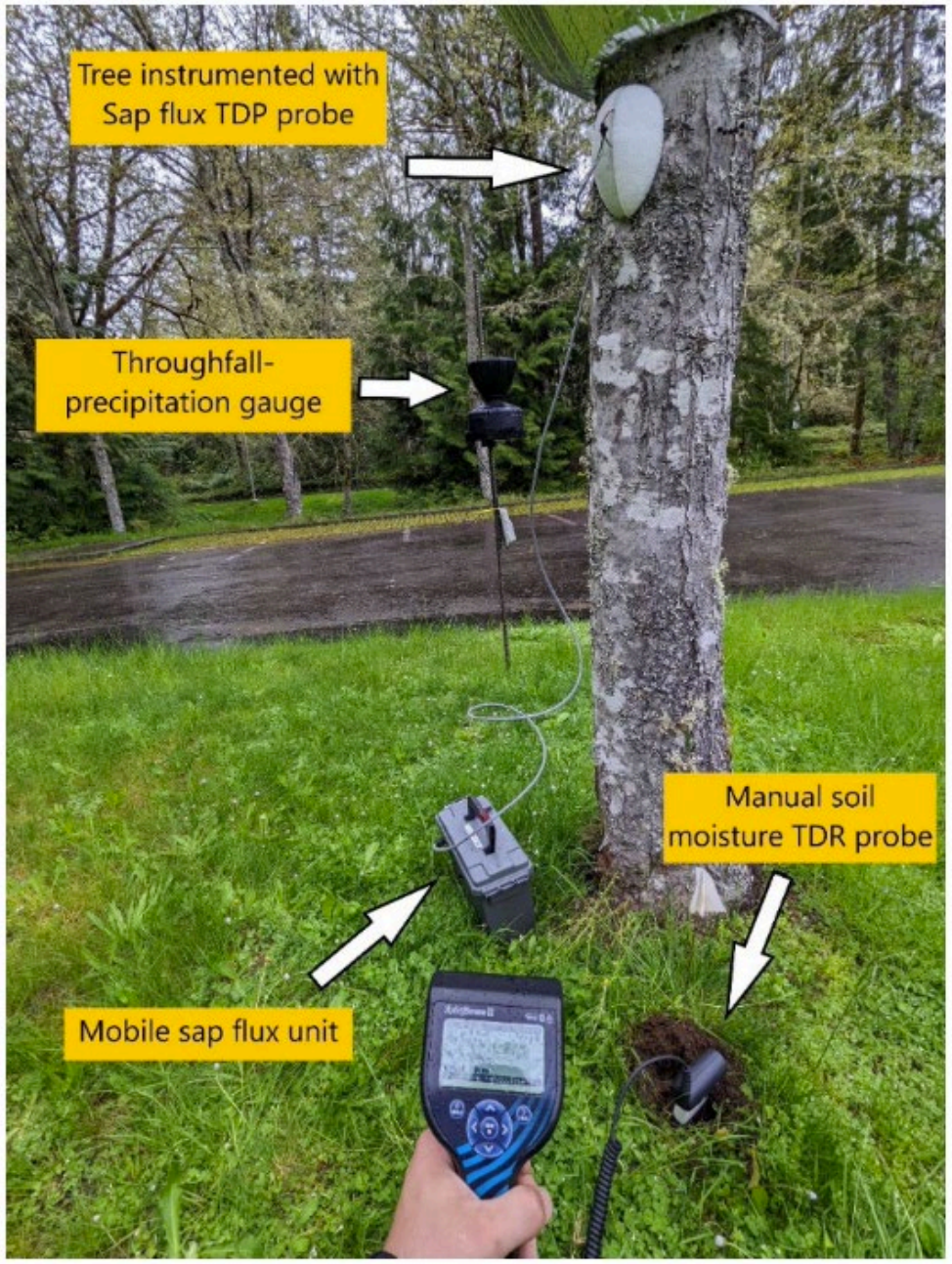
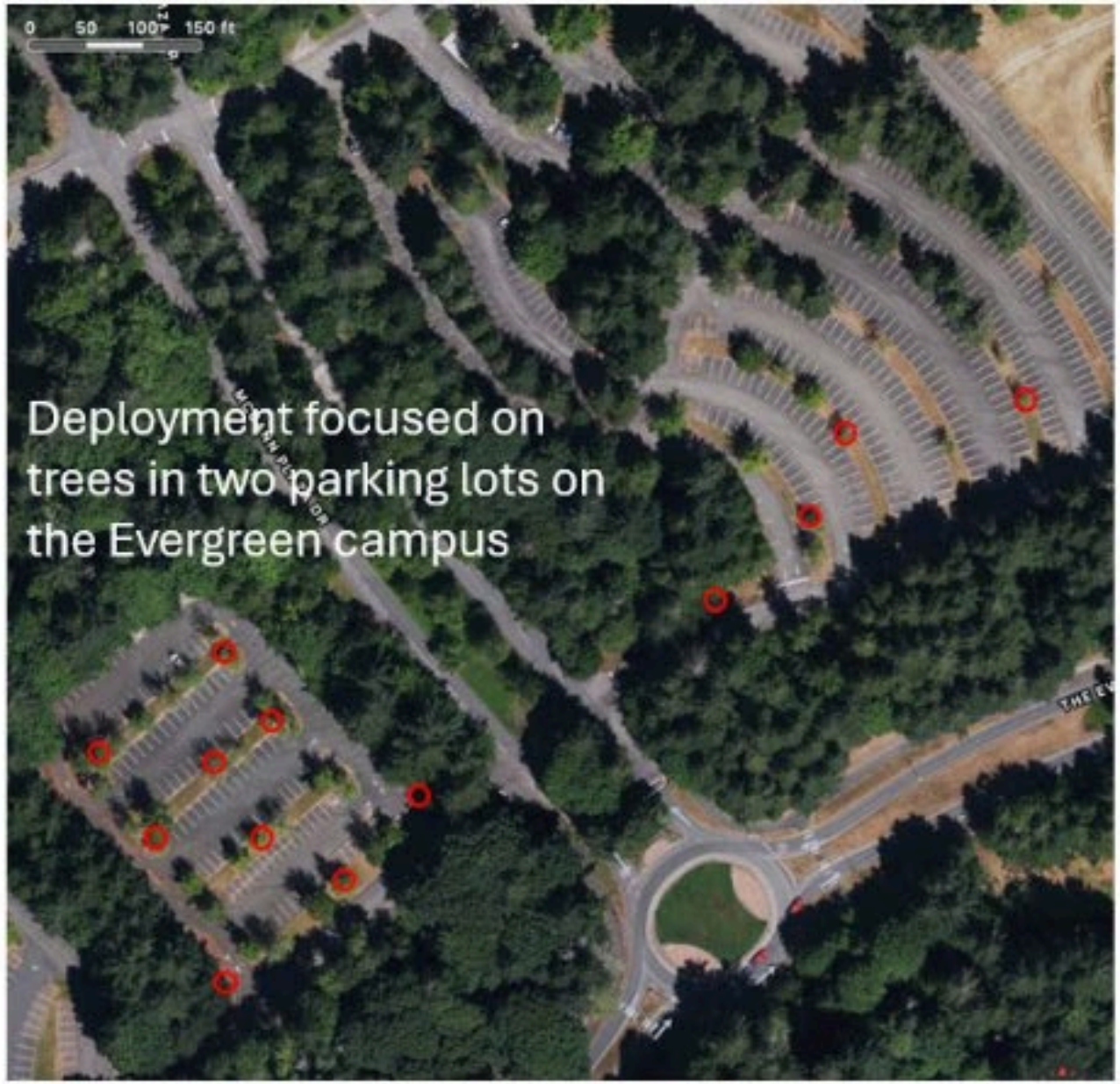


Figure 6. Profile (top) view of rain gauges used to measure canopy throughfall.

Figure 5. Weather station placed in a field north of Parking Lot site.




0 50 100 150 ft
Deployment focused on trees in two parking lots on the Evergreen campus

Size Effect on Water Transpiration by Trees

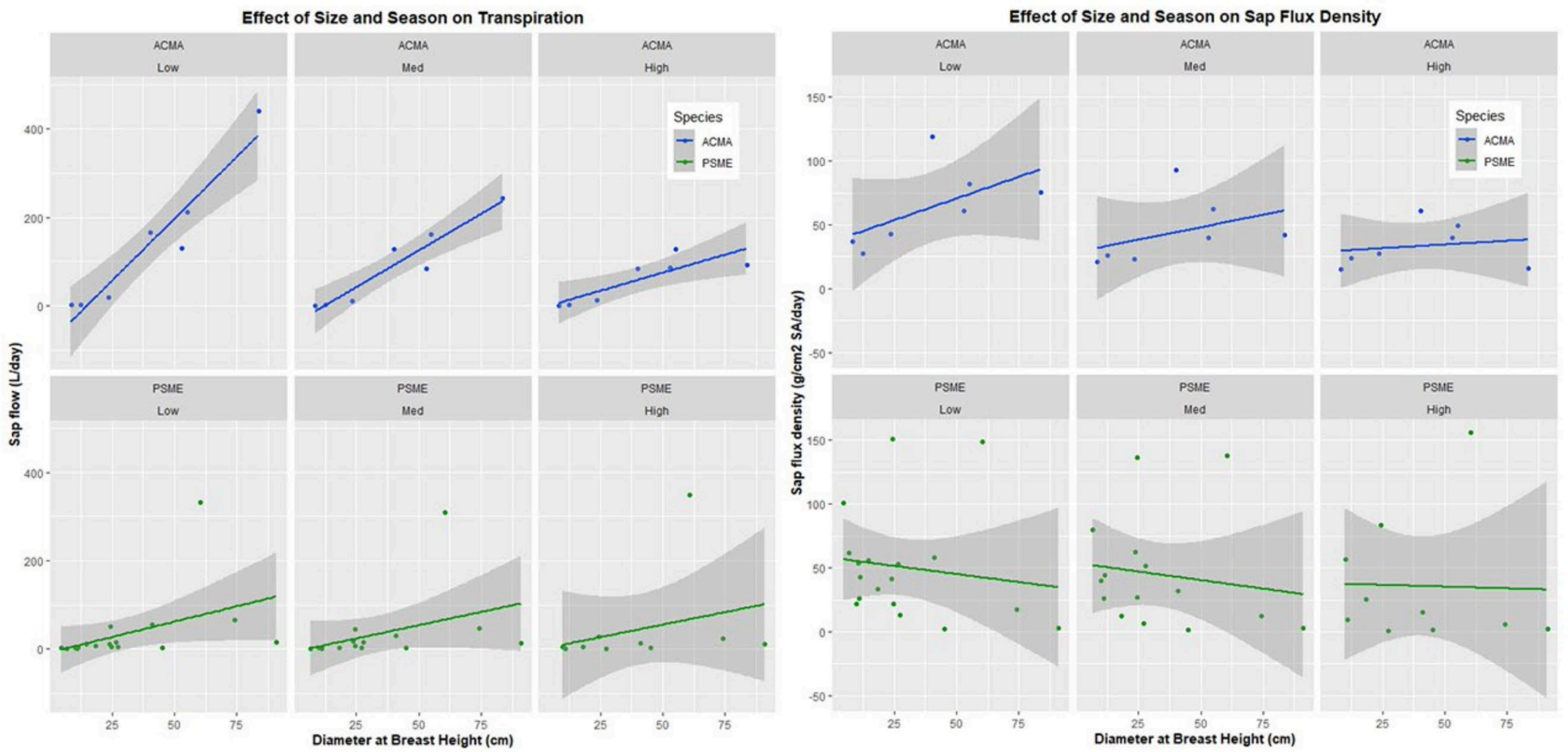


Figure 14. Transpiration (F) and Sap Flux Density (V) from 2023 and 2024 data versus tree size (DBH) separated by VPD class (based on natural breaks in the data: Low, 0.6-1.2 kPa, Medium, 1.2-1.7 kPa, and High, 1.7+ kPa).

Validation of the Mobile Probe Approach

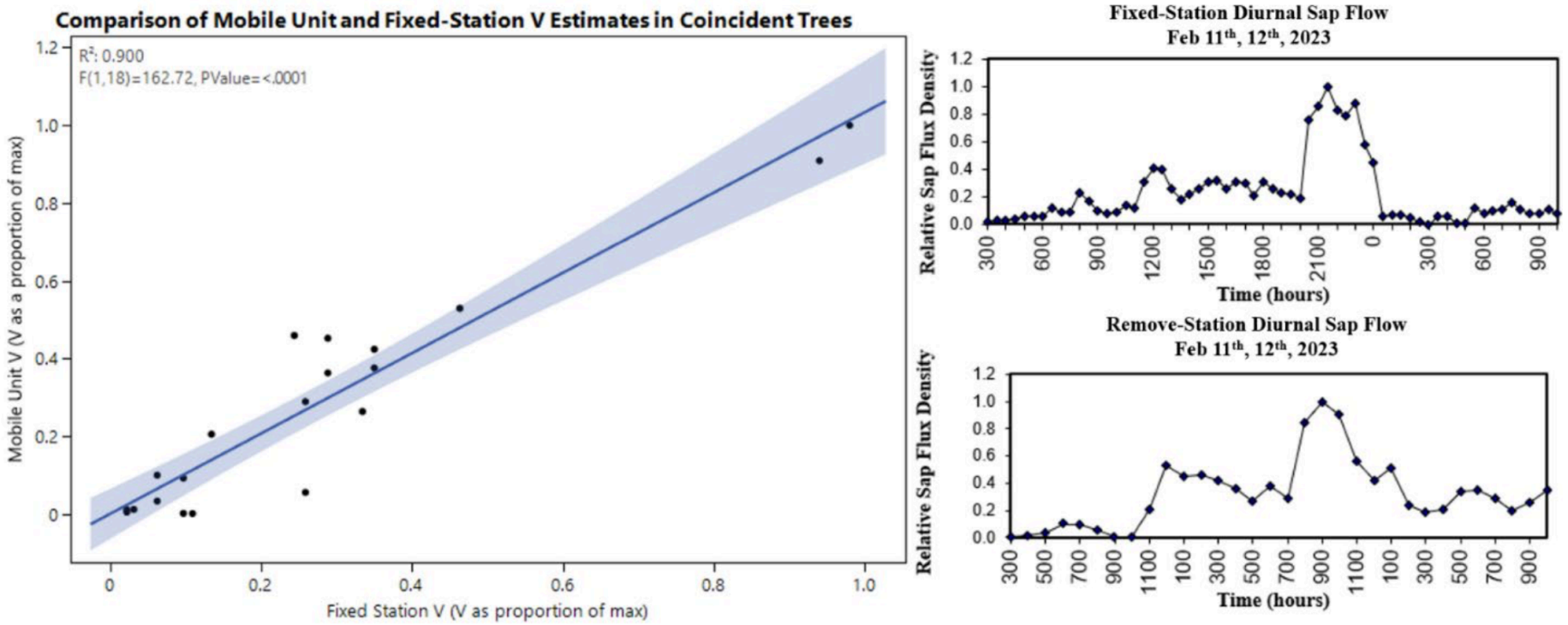
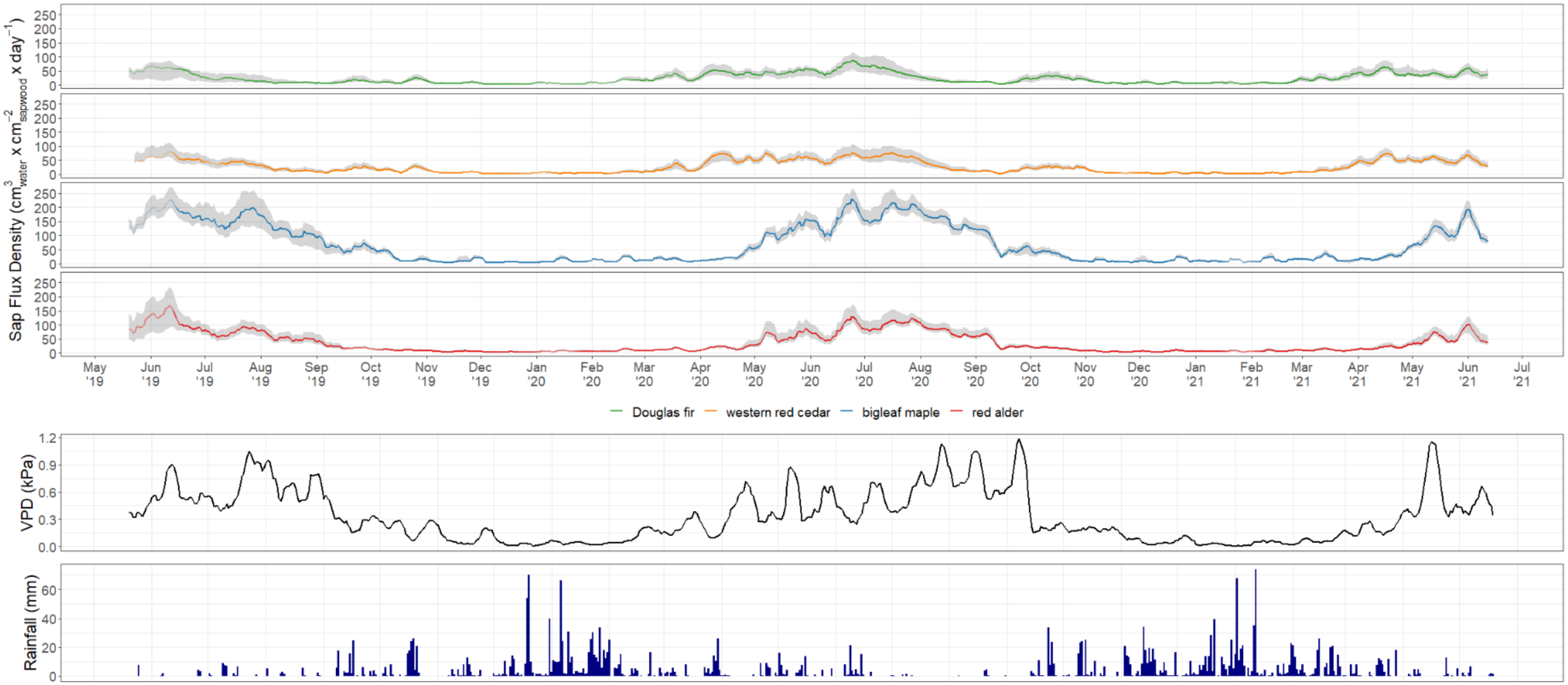
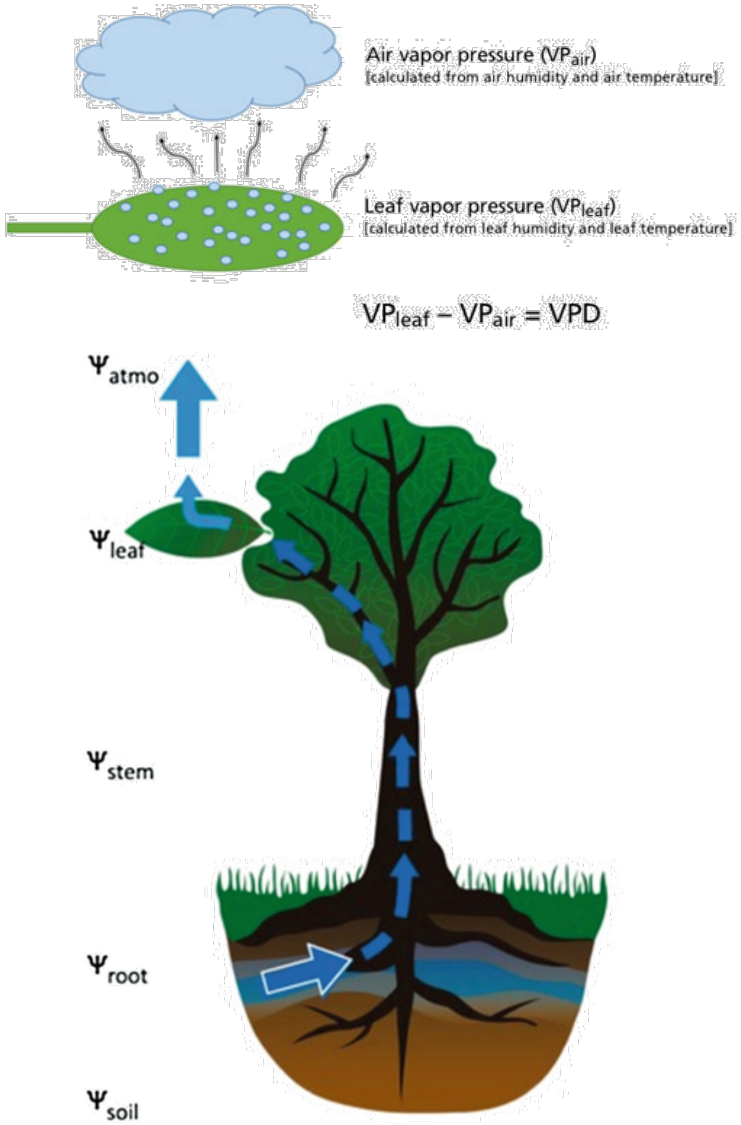


Figure 17. Comparison of relative values from a single tree instrumented with traditional fixed-station and new mobile unit sensors. Left: a direct comparison of relativized values from both methods generating a slope of approximately 1 and close alignment of data from each method (statistical results of a regression analysis are presented along with an R^2 value indicating goodness of fit. The slope of the regression line was 1.01). Right Top: an example diurnal curve from a tree instrumented with fixed-station sap flux methodology February 11-12, 2023. Right bottom: example data from the same tree simultaneously instrumented with mobile unit probes.

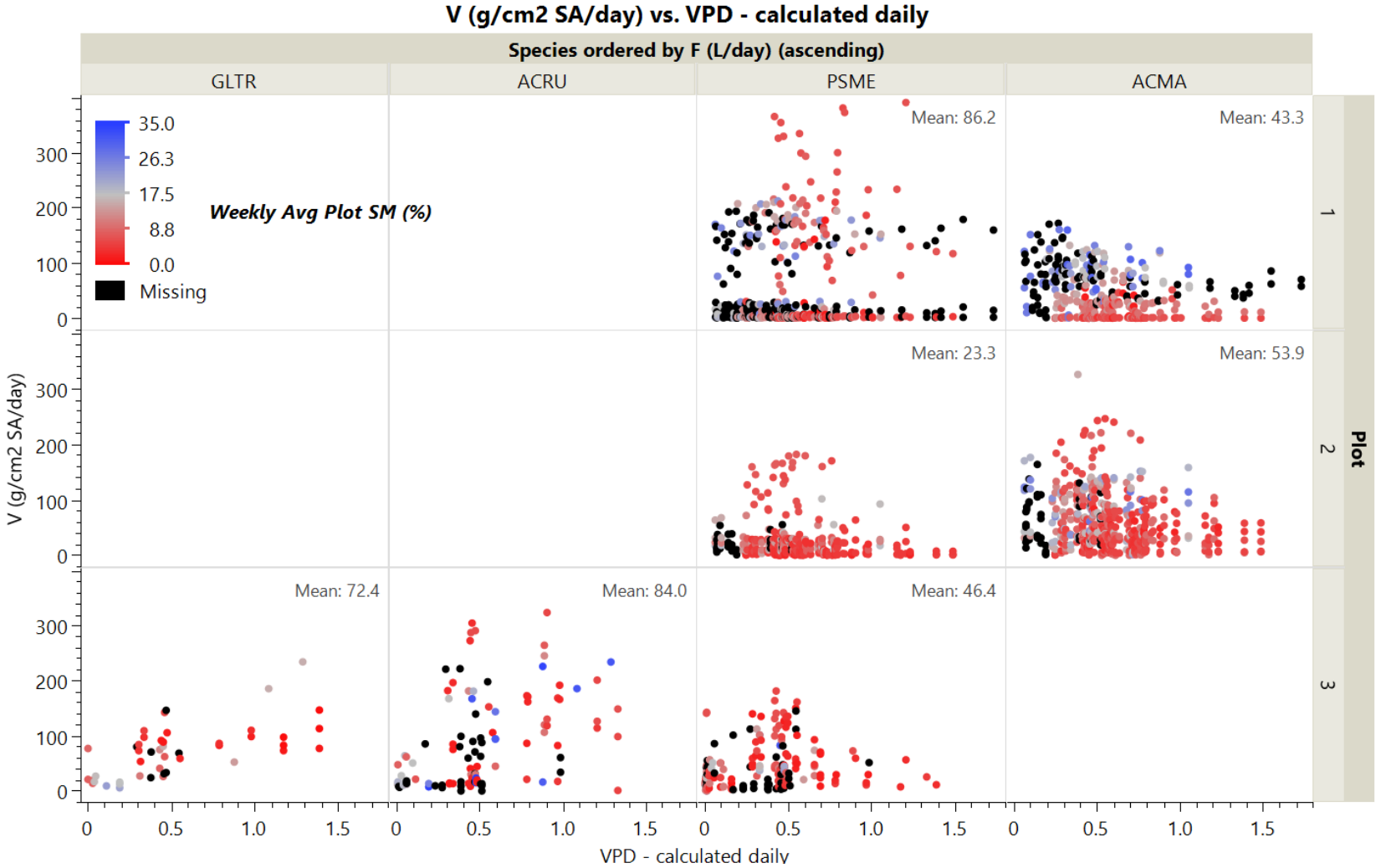
Transpiration Time Series



Vapor Pressure Deficit (VPD) & Transpiration



Lambers et al. (2019)



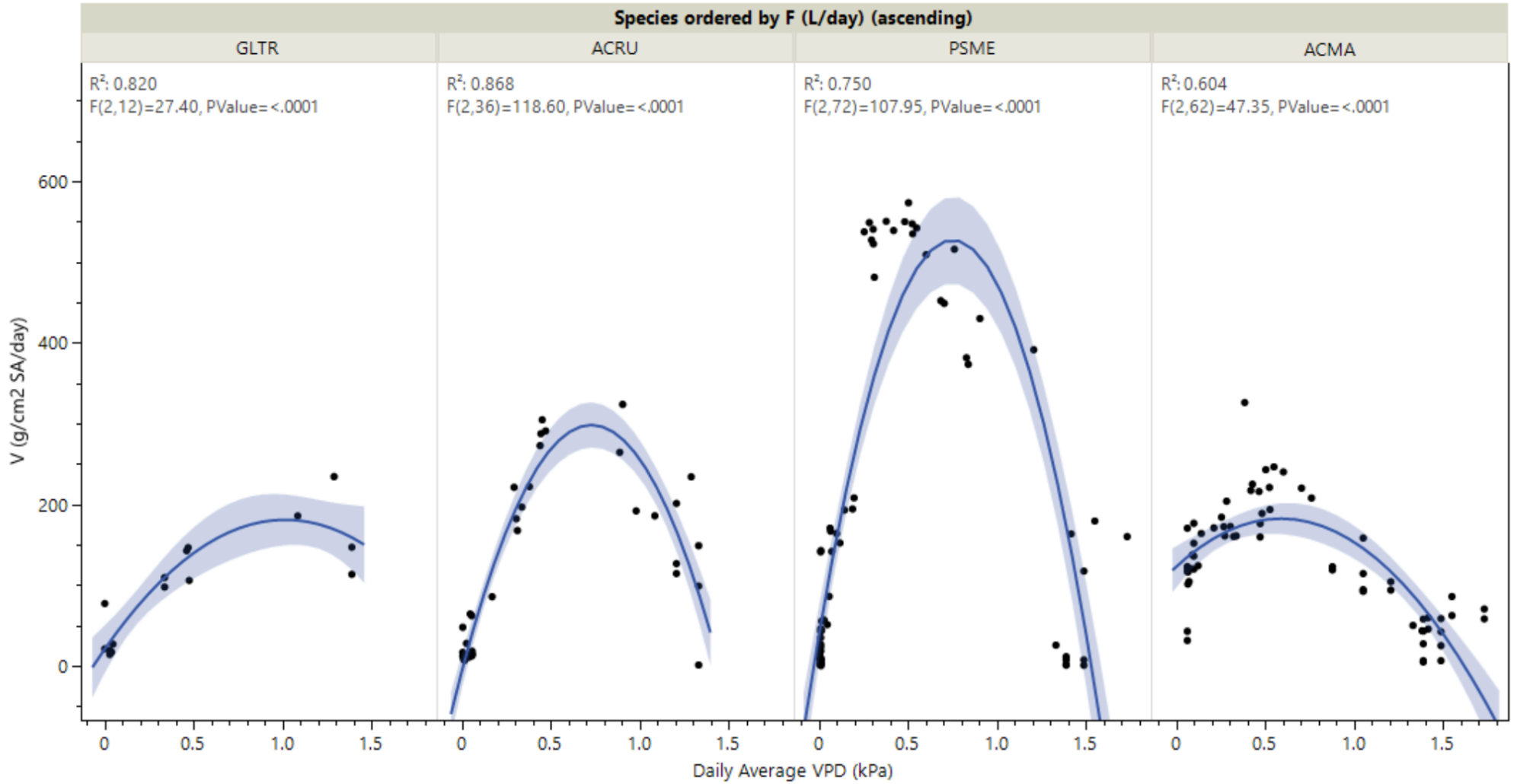


Figure 19. Depiction of daily sap flux density (V) by daily average atmospheric vapor pressure deficit (VPD) using boundary line analysis (excluding 1814 values shown in Figure 17 that were below the top of the response curves). All study sites are combined for this analysis. Regression analysis results are shown in each panel.

Annual Transpiration Trends 2023-2024

- Similar trends and values as Phase I
- Street tree transpiration at similar rates
- Complex interactions with weather

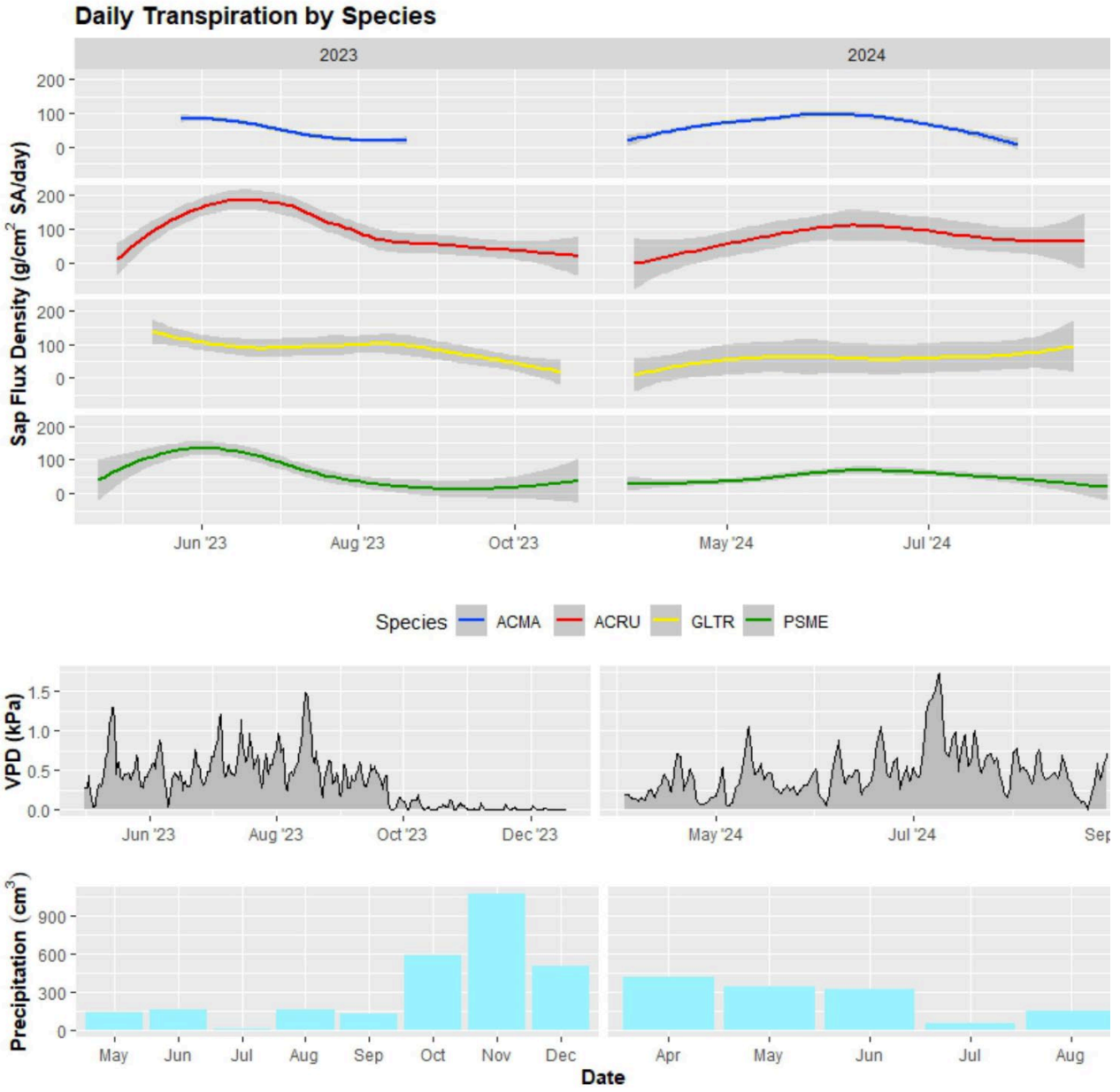
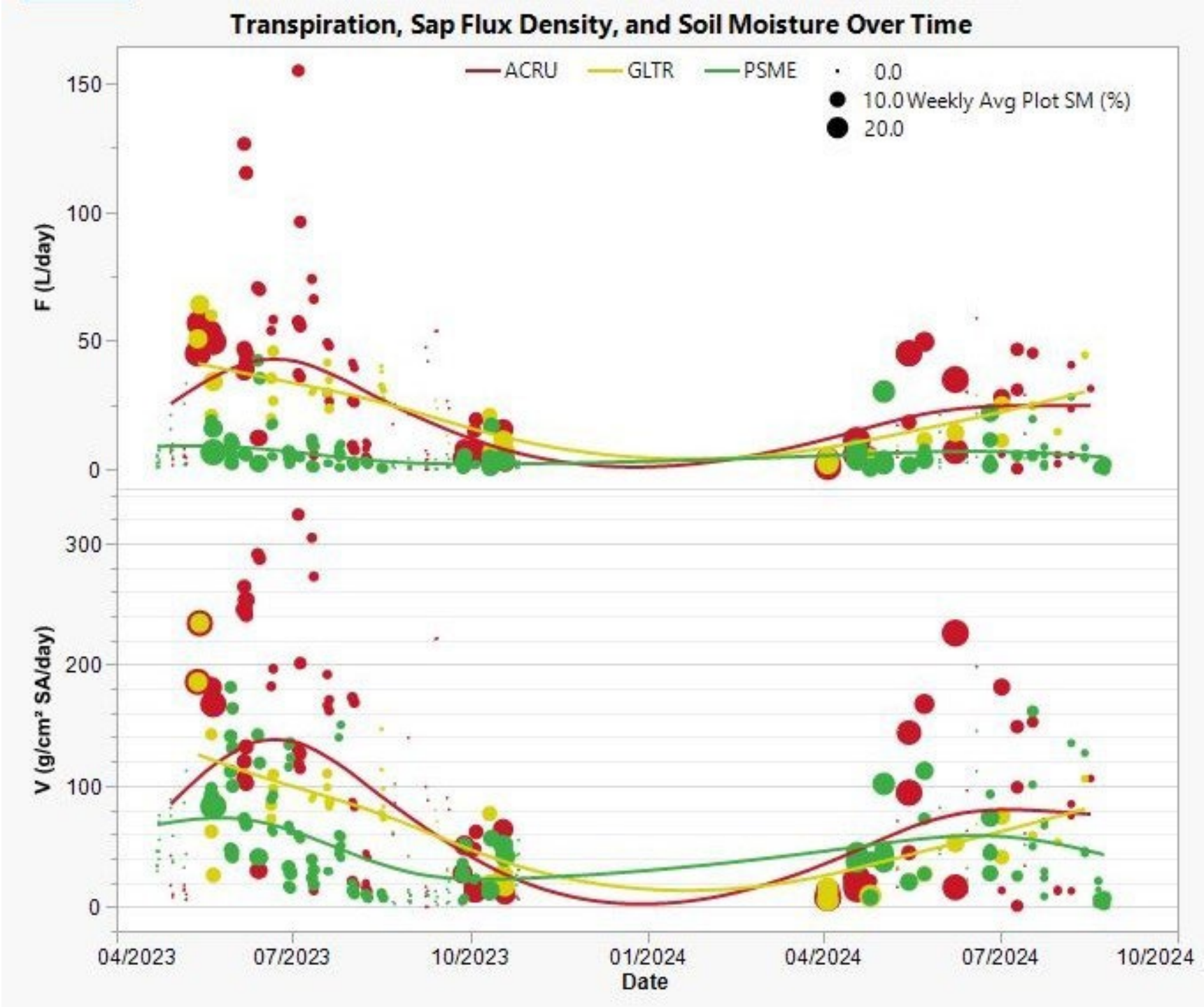


Figure 20. Annual patterns in average daily sap flux density for all species, vapor pressure deficit (VPD; middle panel), and precipitation (bottom panel) in the Phase II study.

Street Tree Sap Flux and Transpiration



Water use for 12 representative trees

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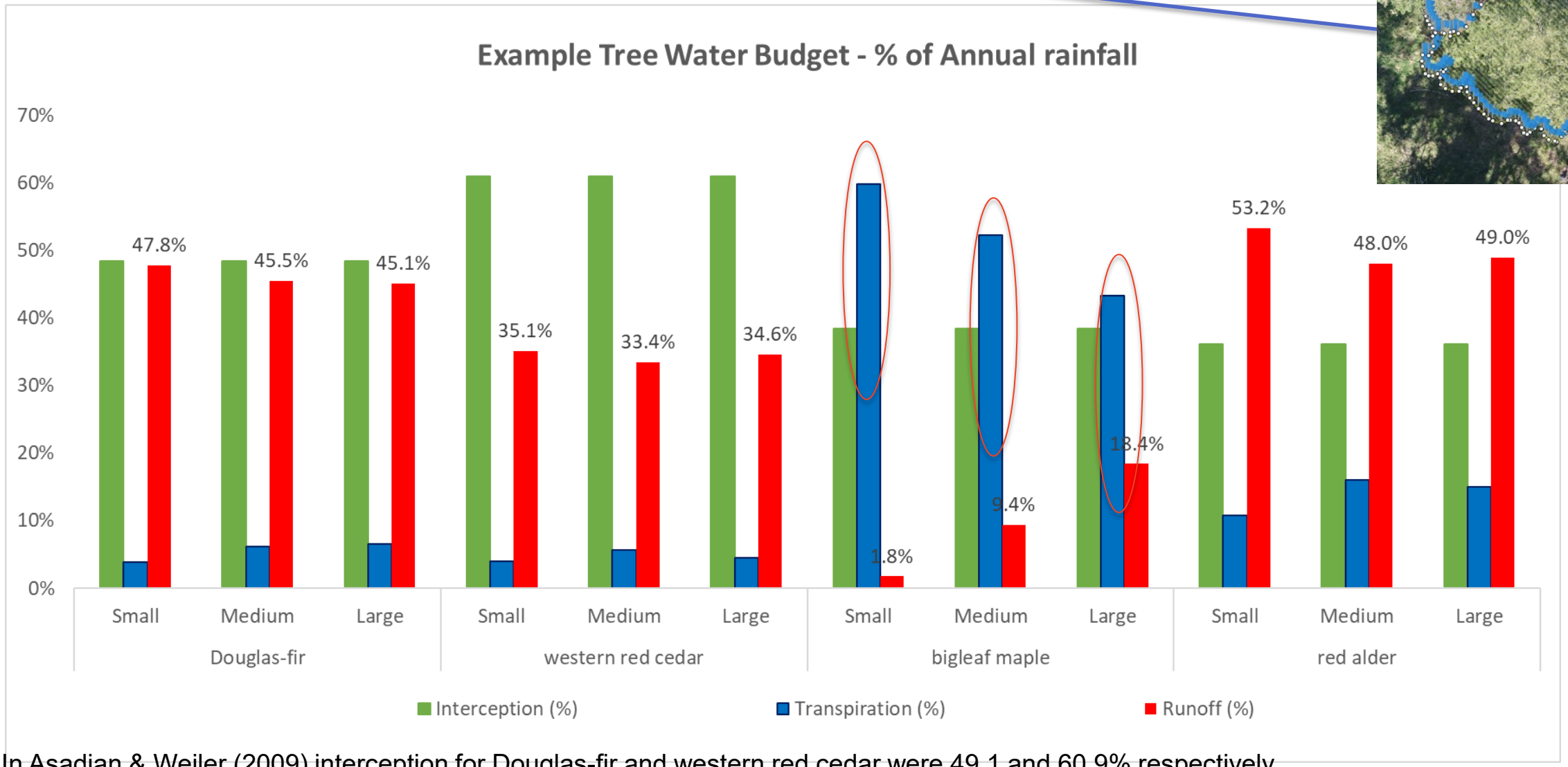

In Asadian & Weiler (2009) interception for Douglas-fir and western red cedar were 49.1 and 60.9% respectively .

Tree Water Budget

Individual Tree Contributions to Stormwater Mitigation **Median Values by Species (Transpiration + Interception)**		
	Annualized Values	
Tree Species	%	cm
Bigleaf maple	52.9%	88.7
Douglas-fir	42.3%	70.9
Honey locust (street tree)	61.3%	102.7
Red maple hybrid (street tree)	65.7%	110.1

Conclusions

- Sap flux density values are scalable across tree sizes from small street trees to large remnant trees
- Greater tree sizes will have greater influences on tree water budgets
- Street tree sap flux values were similar to forested tree values
- Regardless of native or street tree status, trees generally mitigated total stormwater inputs by 40-60%
- Relationships with atmospheric variables and season were similar among similar species, and could be modeled
- There is tremendous potential offered by the mobile sensors to engage communities across Washington in the hydrologic valuation of urban trees, whilst also collecting information on co-benefits these trees offer urban communities. The mobile
- Mobile sensors were shown to be robust, discrete, and capable of providing accurate information.

Thank you!