Measuring Individual Tree Water-use in Mature Native Species to Determine their Benefits for Stormwater: Phase 2

Stormwater Action Monitoring

Effectiveness Study

Prepared for Ecology on behalf of the Stormwater Workgroup by Evergreen State College, Washington State University, and Washington State Department of Natural Resources

Study Highlights

- **Street trees are an effective stormwater management BMP, capable of reducing rainfall from reaching soil or impervious surfaces by as much as 66%.**
- **Street trees in this study showed greater stormwater mitigation potential compared to trees in the forest when accounting for size, likely due to denser canopies and sustained transpiration in exposed locations.**

Goal & Background

Urban trees in parks, on private city lots, and street-side can provide excellent opportunities to mitigate the effects of stormwater runoff in Puget Sound. This study was designed to continue and expand the SAM study's first phase, which evaluated stormwater mitigation potential of mature common native evergreen and deciduous trees in forested locations. See SAM Fact Sheet #26 for more information on Phase 1.

Phase 1 of this study developed a hydrologic dataset demonstrating how mature trees in forests capture rainfall and mitigate stormwater, with interception patterns varying by canopy type and storm intensity. Given that street trees differ in size from mature forest trees, Phase 2 focused on estimating transpiration and interception in smaller street trees. In this phase new mobile sap flow measurement technology was used to measure transpiration rates. This study aimed to determine if tree size influences sap flux velocity and quantify how much rain and runoff is captured by smaller street trees.

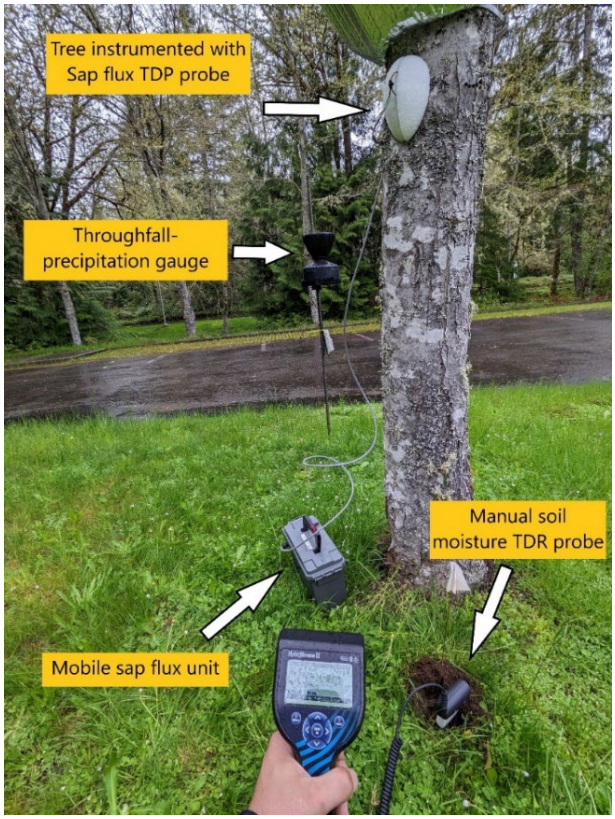

Figure 1. Instruments used at each site include a mobile sap flux probe unit attached to the tree trunk, soil moisture probe, and precipitation gauge installed beneath the tree canopy.

Project Findings

On average, sap flux velocity is independent of tree size in young mature trees for both bigleaf maple and Douglas-fir. When scaled up, total tree transpiration scaled strongly with size. Larger trees, with more sapwood, transpired more water over the growing season. Total tree transpiration was mildly correlated with vapor pressure density, a measure of how hot or dry a climate is. As in Phase 1, the results showed that bigleaf maples transpired at a higher rate. Douglas-fir transpired more water during the shoulder seasons, and much less during mid-summer dry periods – a potential adaptation to summer drought.

Collectively improving stormwater management

Stormwater Action Monitoring (SAM) is a collaborative, regional stormwater monitoring program that is funded by more than 90 Western Washington cities and counties, the ports of Seattle and Tacoma, and the Washington State Department of Transportation. SAM's goal is to improve stormwater management to reduce pollution, improve water quality, and reduce flooding. We do this by measuring stormwater impacts on the environment and evaluating the effectiveness of stormwater management actions.

Predicting the impact of trees on local water budgets and stormwater capture depends on tree transpiration and interception and varies by tree species and the timing of precipitation. Across the two phases of the study, trees reduced 42-66% of precipitation through transpiration and interception each year. The Phase 2 results found street trees had a higher impact on water use compared to forest trees (61-66% versus 42-53%), likely due to their denser canopies and sustained transpiration on hot, dry summer days. In terms of annual water budget volumes, Douglas-fir mitigated approximately 71 cm of water, while bigleaf maple mitigated 89 to 103 cm. Compared to the site's average annual rainfall of 130 cm, tree canopies could reduce precipitation reaching soils and impervious surfaces by 42-66%.

Table 1: Water budgets: Median values of transpiration plus interception by tree position and species as a percentage of total precipitation and amount in centimeters

Tree Position & Species	Year 2023 %	Year 2023 cm	Year 2024 %	Year 2024 cm	Annualized Values %	Annualized Values cm
Forest: Bigleaf maple	27.6%	34.4	126.5%	54.3	52.9%	88.7
Forest: Douglas-fir	30.6%	38.2	76.2%	32.7	42.3%	70.9
Street: Honey locust	57.2%	71.4	73.1%	31.3	61.3%	102.7
Street: Red maple hybrid	63.3%	79.0	72.6%	31.1	65.7%	110.1

Recommendations

We recommend mature tree retention and tree planting in urban settings to the greatest extent feasible. Whenever possible, use evergreen trees for stormwater management in the wetter months.

Why does this study matter?

Urban trees in parks, on private city lots, and street-side can provide excellent opportunities to mitigate the effects of stormwater runoff and are an effective stormwater BMP. Trees intercept rainfall that would otherwise fall on streets, sidewalks, and other impervious surfaces. They also draw water from the soil through uptake and transpiration processes, increasing the water holding capacity over the season. The act of intercepting and transpiring water can shift the rainfall runoff relationship in the landscape.

What should stormwater managers do with this information?

Municipal Stormwater Permits issued in 2024 now require permittees map tree canopy and adopt tree canopy goals that support stormwater management. Information from this study can inform how jurisdictions plan and manage existing tree canopy and where canopy for stormwater management is most beneficial.

Stormwater designs may be able to reduce the size of Flow Control BMPs if they retain mature trees and apply 'tree credits' per the SWMM BMP. Evergreen trees provide distinct advantages for winter and spring hydrology, but the most appropriate tree for the site should be chosen.

What will Ecology do with this information?

Ecology encourages planting and maintaining trees as part of a stormwater management program. As with the Phase 1 study, Ecology will add a reference to this study in BMP T5.16/F6.6.

For more information, including the final report, see the website at

ecology.wa.gov/sam

To request an ADA accommodation, contact Ecology by phone at 360-407-6600 or email at chelsea.morris@ecy.wa.gov, or visit https://ecology.wa.gov/accessibility. For Relay Service or TTY call 711 or 877-833-6341