Urban Trees for Stormwater Year-2 Results

Measuring individual tree water use in the Pacific Northwest to determine their benefits for stormwater management

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[1]**Washington State University**
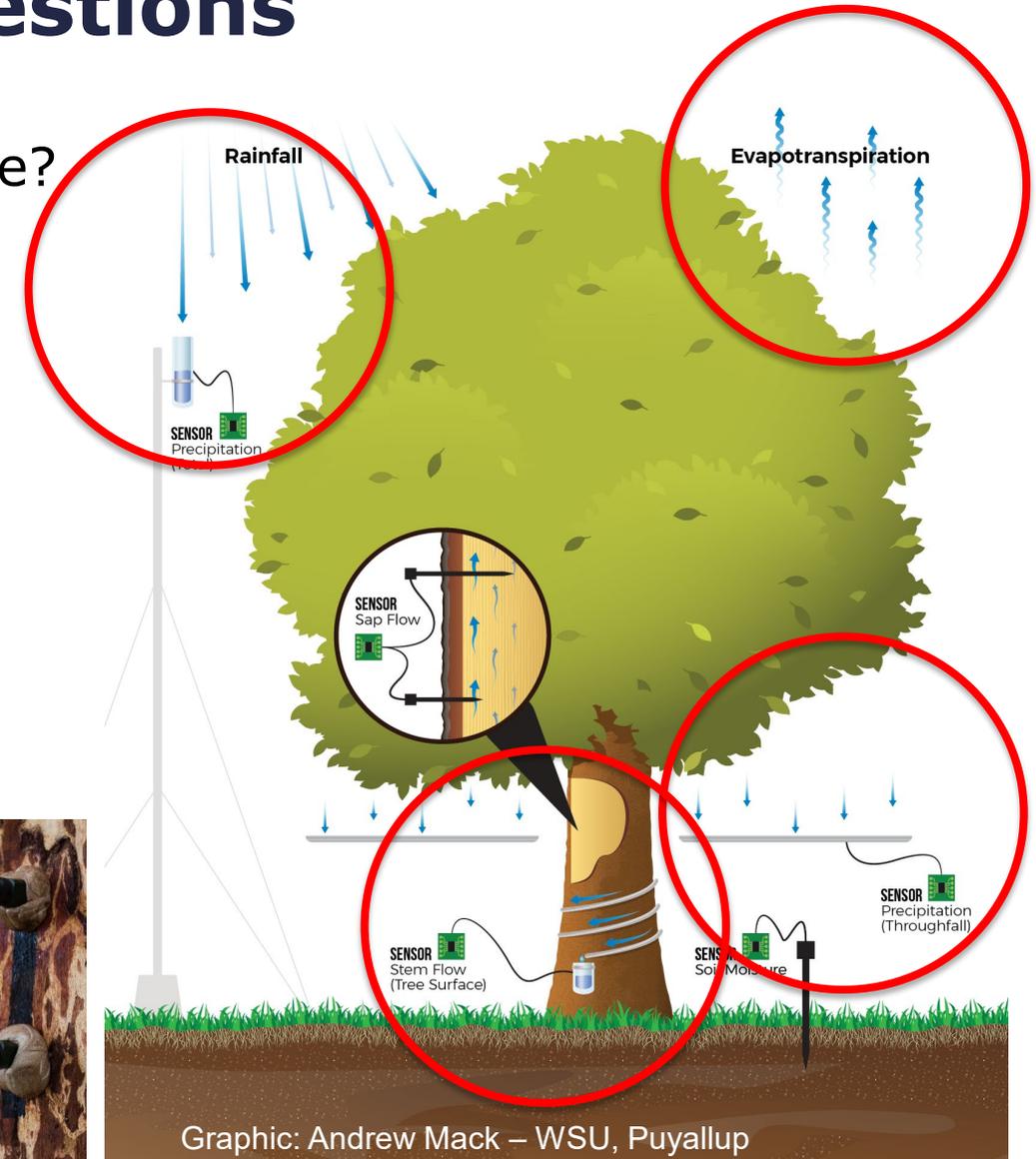
[2]**Evergreen State College**

[3]**Clemson University**

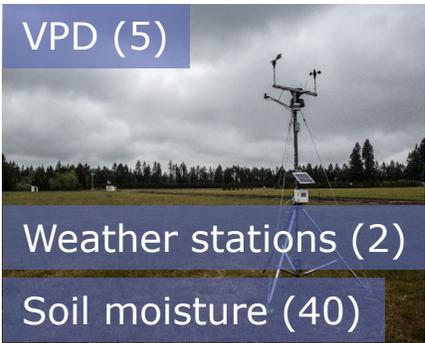[4]**Washington Dept. of Natural Resources**

9/15/2021

Individual Tree Water Use Questions

> What environmental factors impact tree water use?

> Are there differences between tree species?

> What seasonal variability do we see?

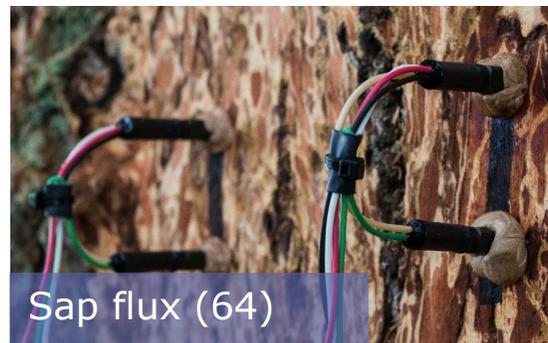> What are the implications for stormwater management?
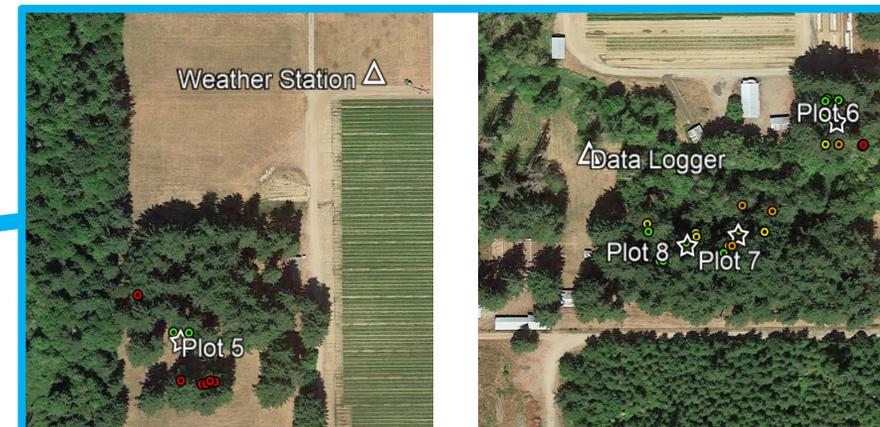
Environment

VPD (5)

Weather stations (2)

Soil moisture (40)

Interception

Stemflow (24)
Throughfall (32)

Transpiration

Sap flux (64)

Rainfall

Evapotranspiration

SENSOR
Precipitation

SENSOR
Sap Flow

SENSOR
Stem Flow
(Tree Surface)

SENSOR
Soil Moisture

SENSOR
Precipitation
(Throughfall)

Graphic: Andrew Mack – WSU, Puyallup

Study Locations

South Puget Sound Region

Organic Farm

Parking Lot

The Evergreen State College

Plot 1

Plot 2

Weather Station

Plot 3

Plot 4

Weather Station

Data Logger

Plot 6

Plot 8   Plot 7

Plot 5

Webster Forest Nursery

North

South

Methods

Sap Flux Trees

Stem Flow

Throughfall

Data Logger

Collection Buckets
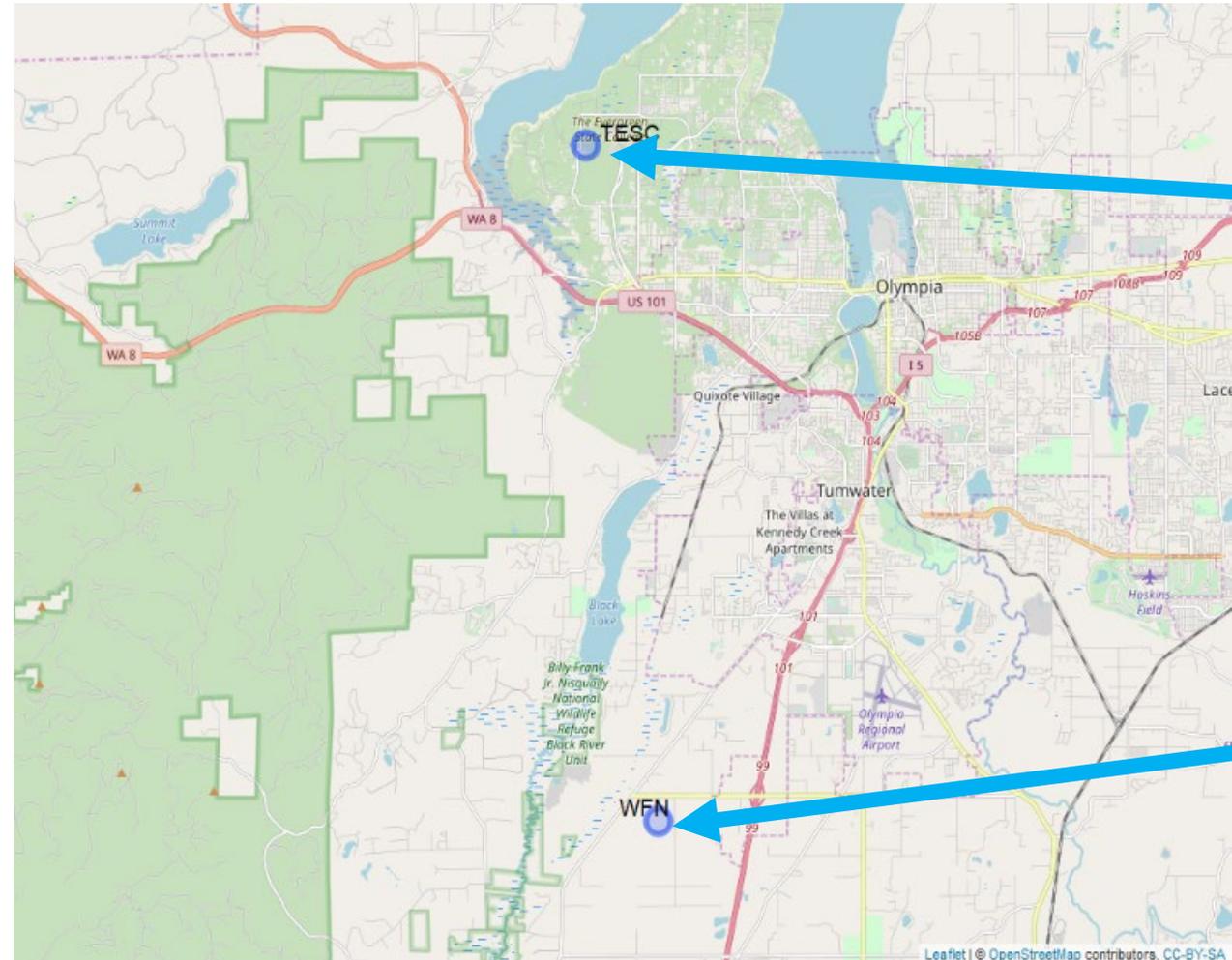
Inside of Troughs

Size Distribution of 64 Trees
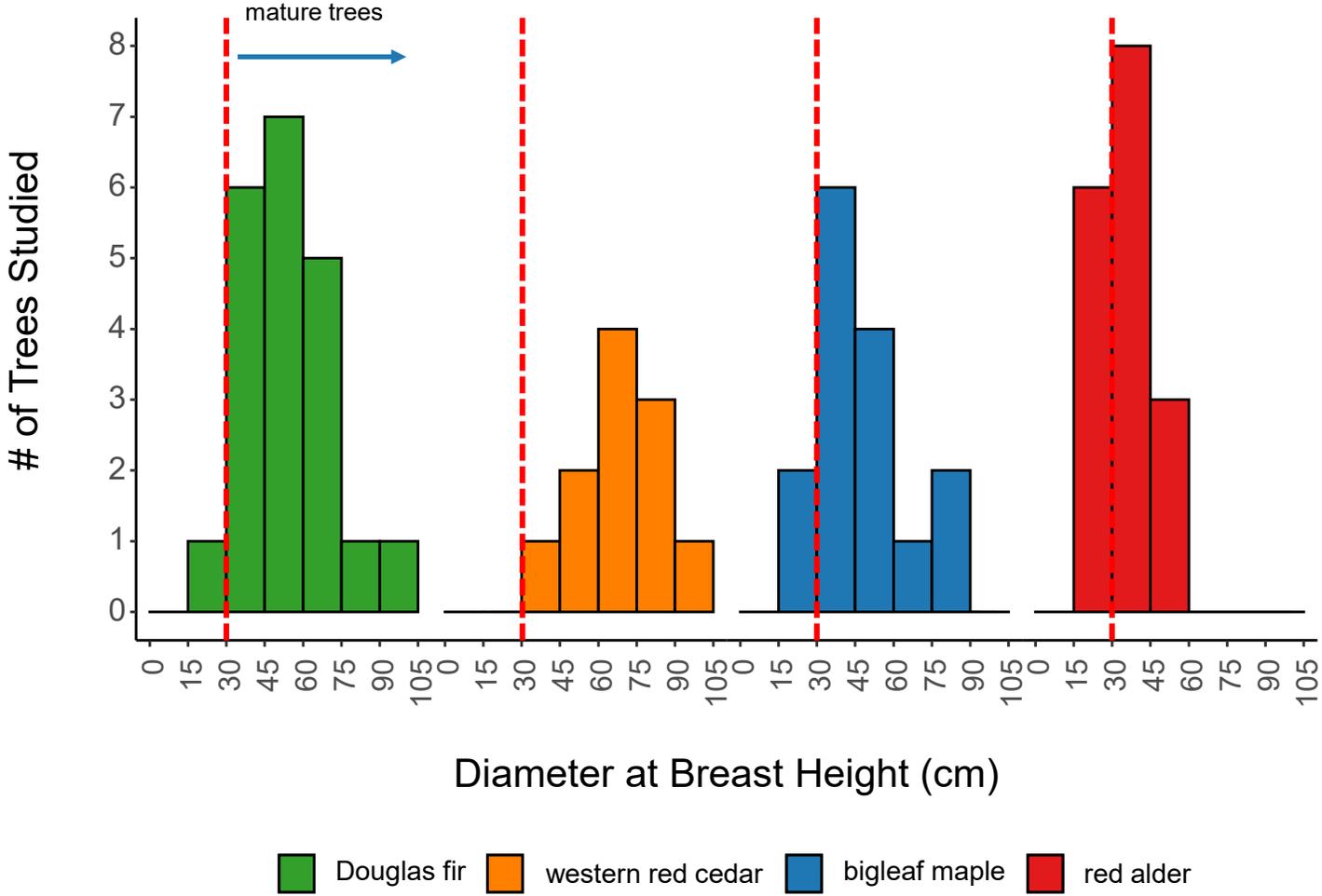
Stemflow Results

% Stemflow by Species

0.07%   0.06%   0.05%   0.26%

mean w/ SE

Y-axis: % of Total Precipitation
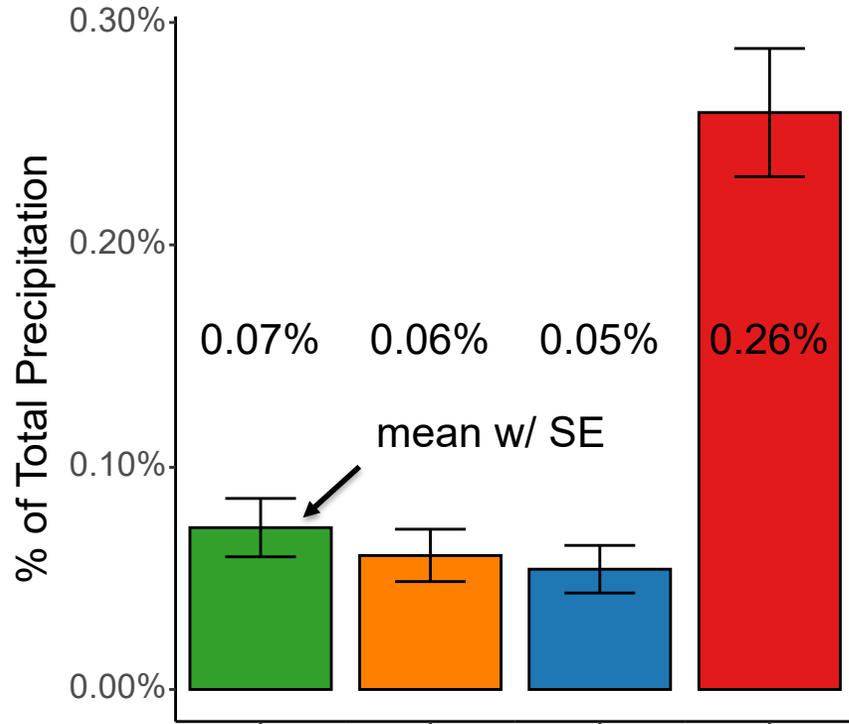
Stemflow grouped by storm to

Y-axis: % of Total Precipitation

X-axis: Rainfall (mm) — 2-5, 5-10, 10-15, 15-20, 20-25, 25-50, 50-100, >100 (repeated per species)
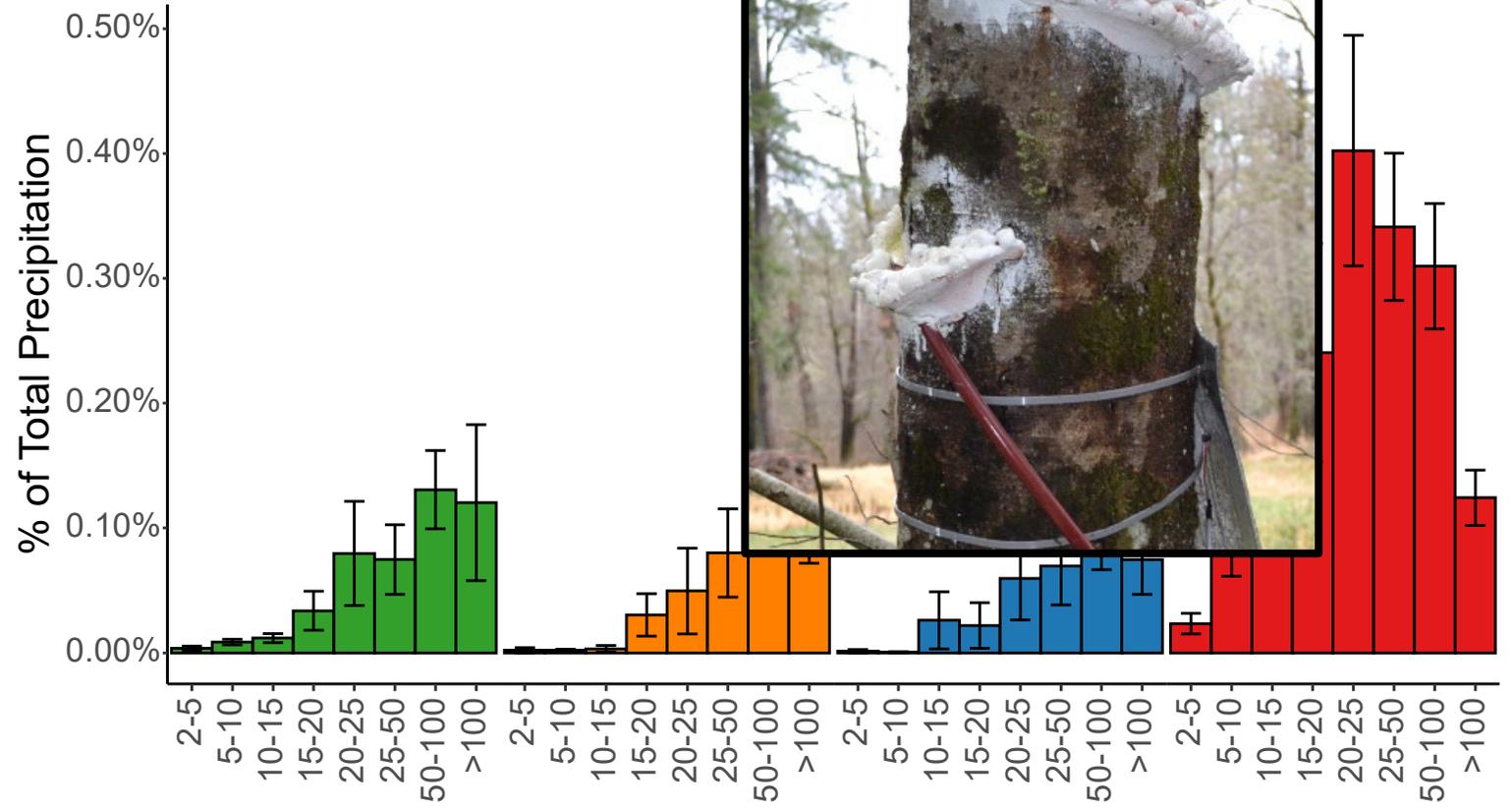
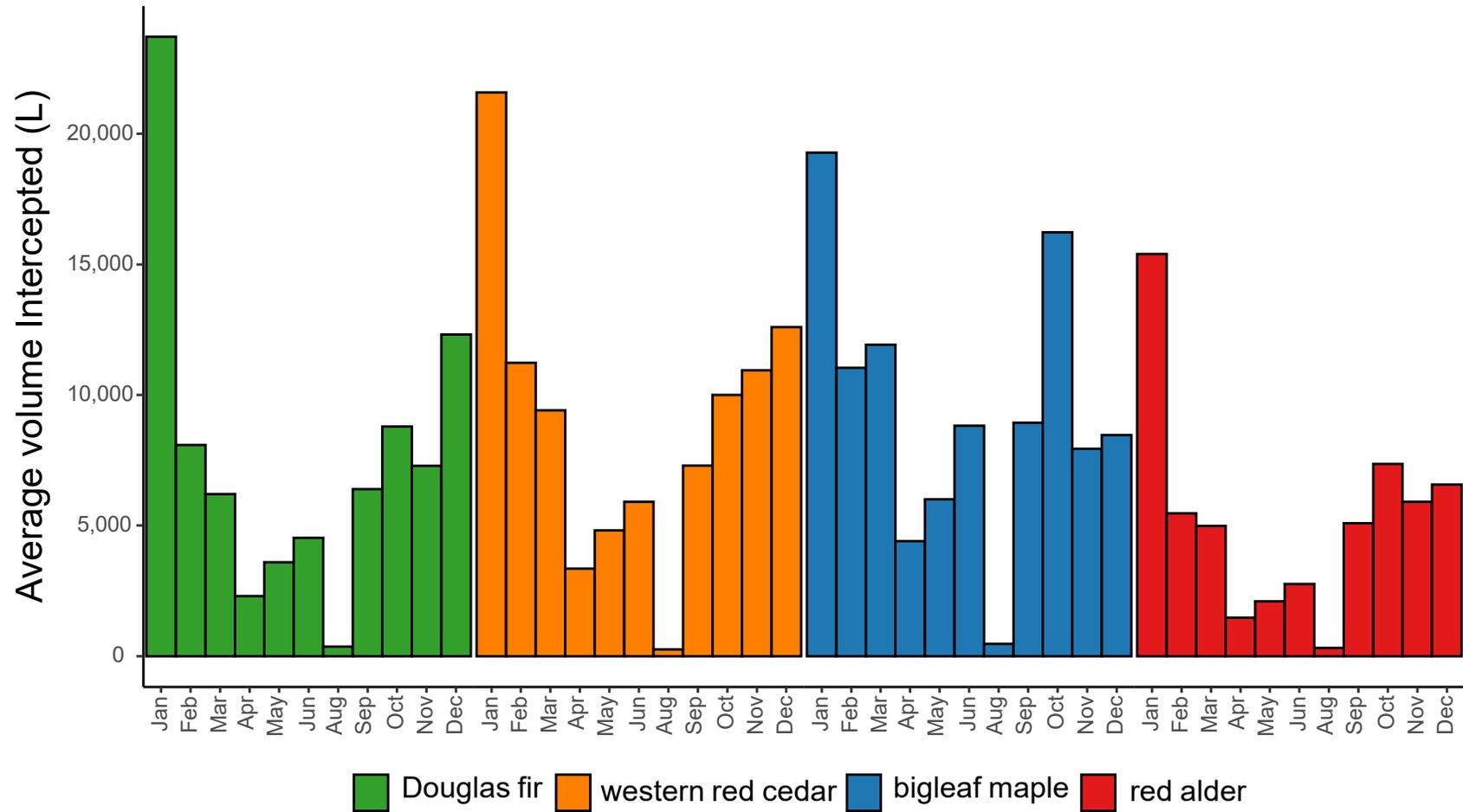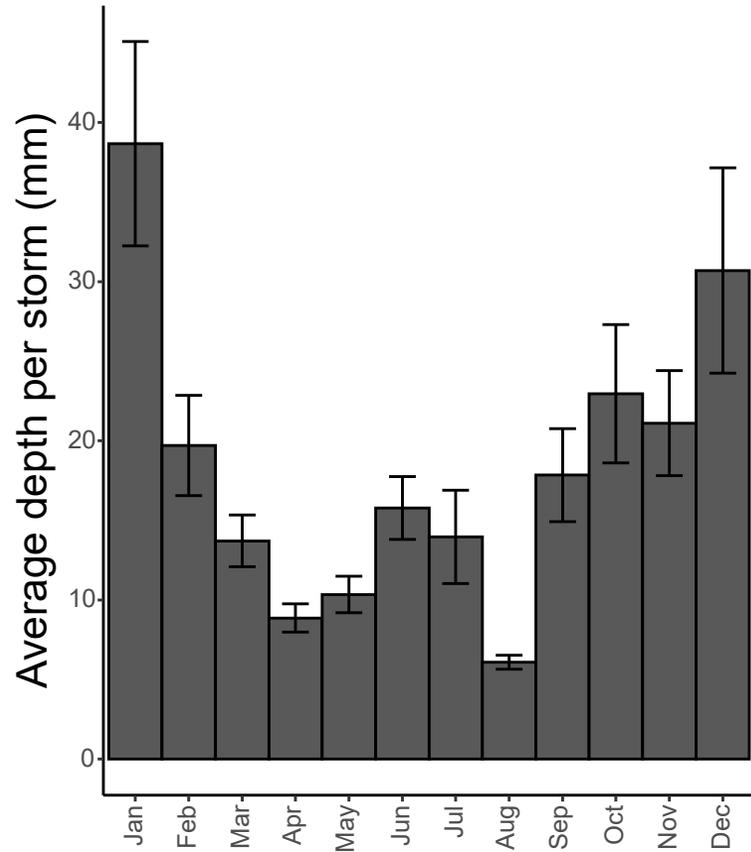Legend: Douglas fir, western red cedar, bigleaf maple, red alder

Interception Results (Volumes)

Per tree average volumes grouped by species and month

Legend: Douglas fir, western red cedar, bigleaf maple, red alder

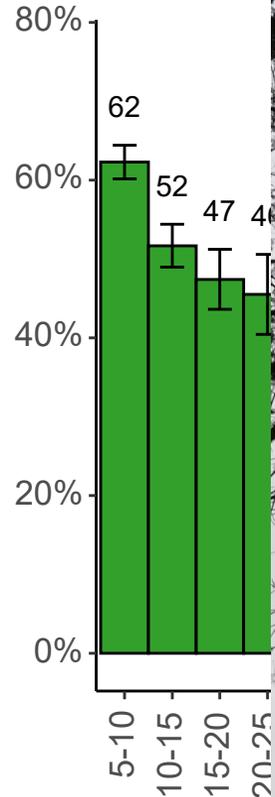*not enough usable data in July – clogging and sensor issues

Interception Percents

% Interception by Season (Leaf On/Off)

Average % Canopy Interception

- 60% — 59 (65), 45 (145), 67 (64), 59 (145), 62 (65), 31 (145), 49 (65), 32 (145)
- sample size ↓

Legend: Douglas fir (green), western red cedar (orange)

Leaf-On / Leaf-Off categories

Average %

- 80%
- 62, 52, 47, 46
- 5-10, 10-15, 15-20, 20-25
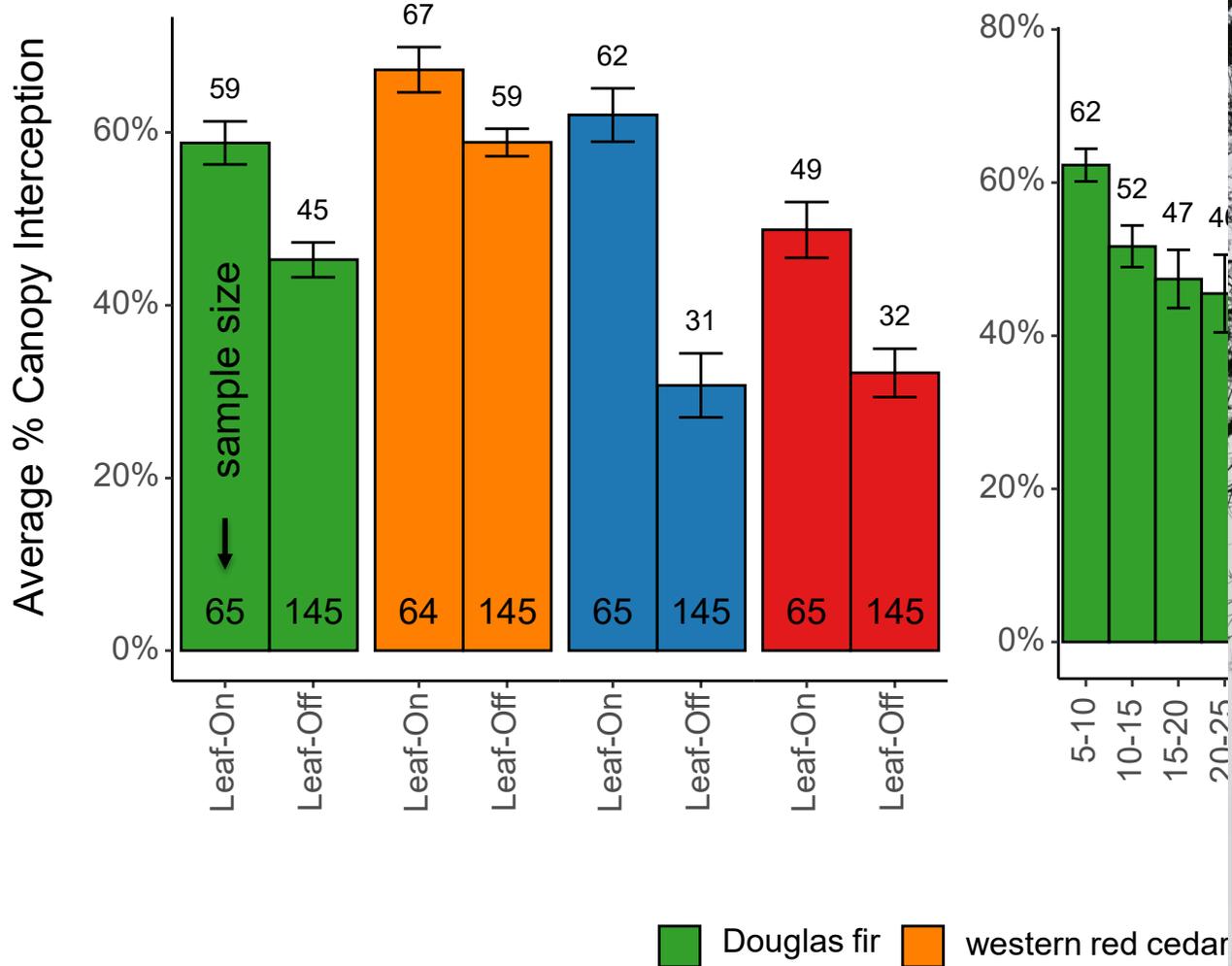
Vapor Pressure Deficit (VPD) vs. Transpiration

$VP_{leaf} - VP_{air} \equiv VPD$
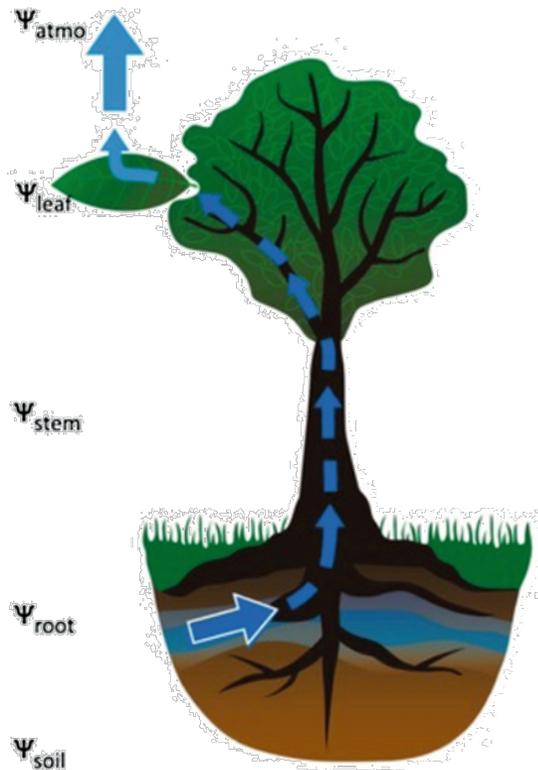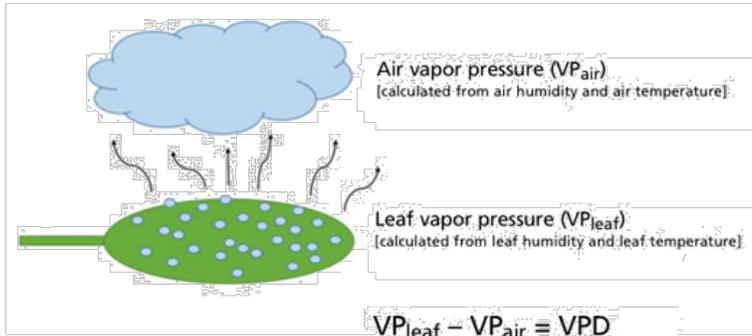
Lambers et al. (2019)

Not a linear relationship
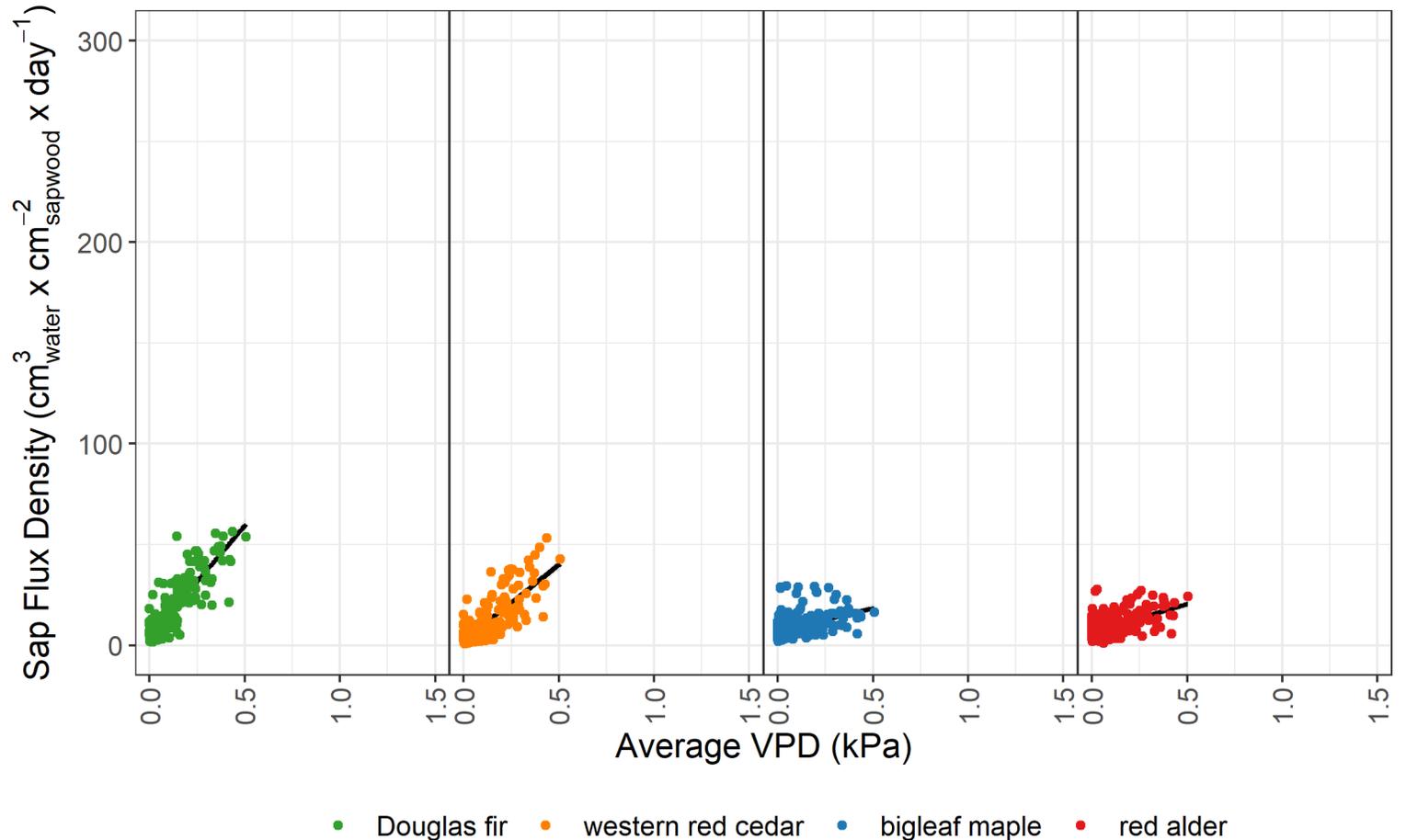
*Daily average VPD vs. sap flux for November to March (soil moisture > 20%)

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Transiration by VPD
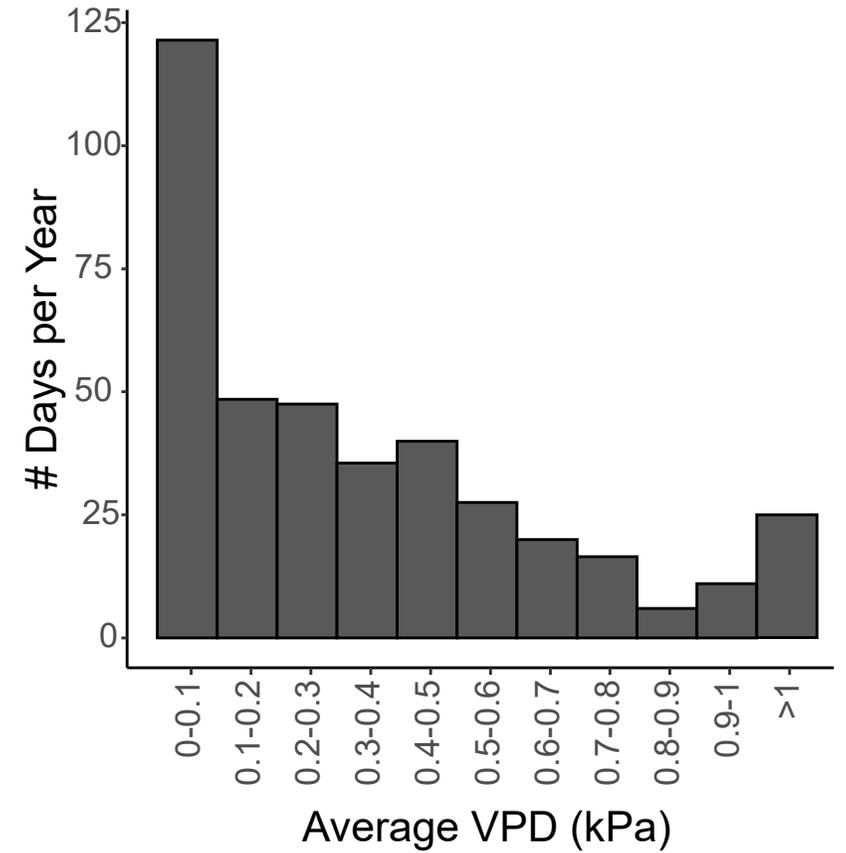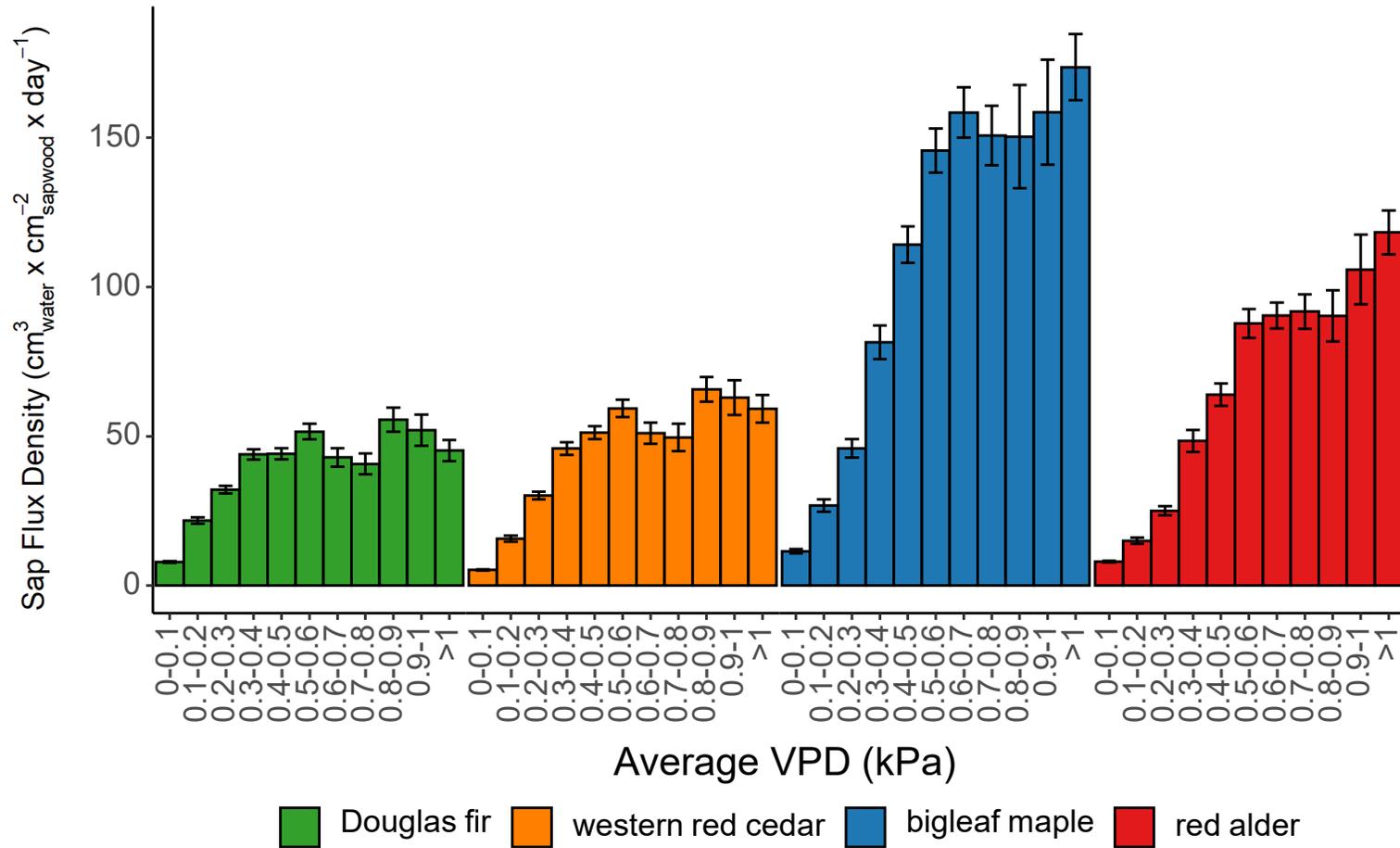
Transcription Time Series

evergreen > deciduous during early spring

2-year mean:

29

30

71

43
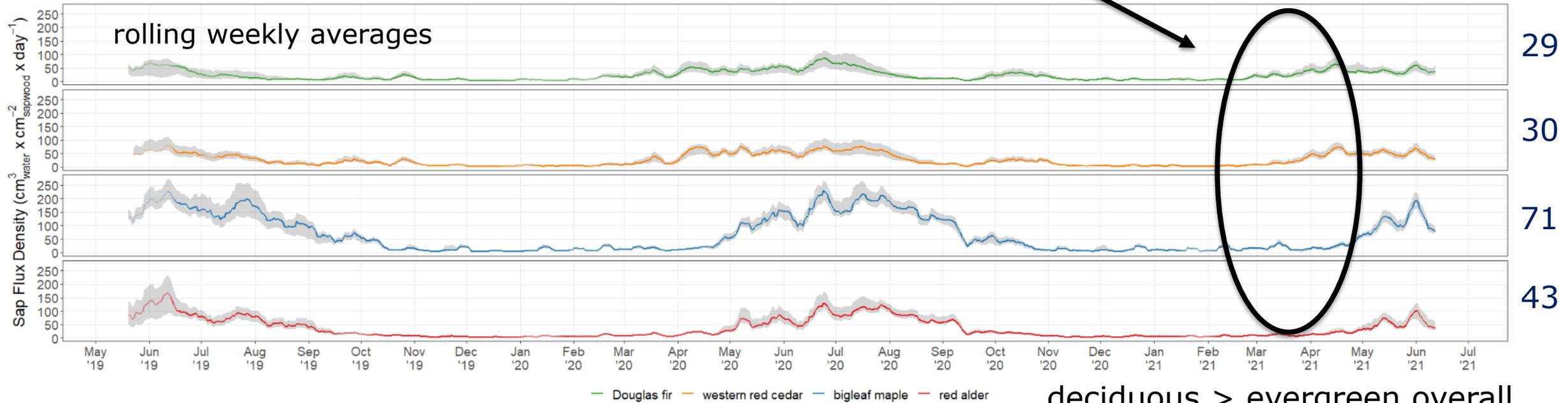
deciduous > evergreen overall

rolling weekly averages

Legend: Douglas fir — western red cedar — bigleaf maple — red alder

Sap Flux Density ($cm^3_{water} \times cm^{-2}_{sapwood} \times day^{-1}$)

VPD (kPa)
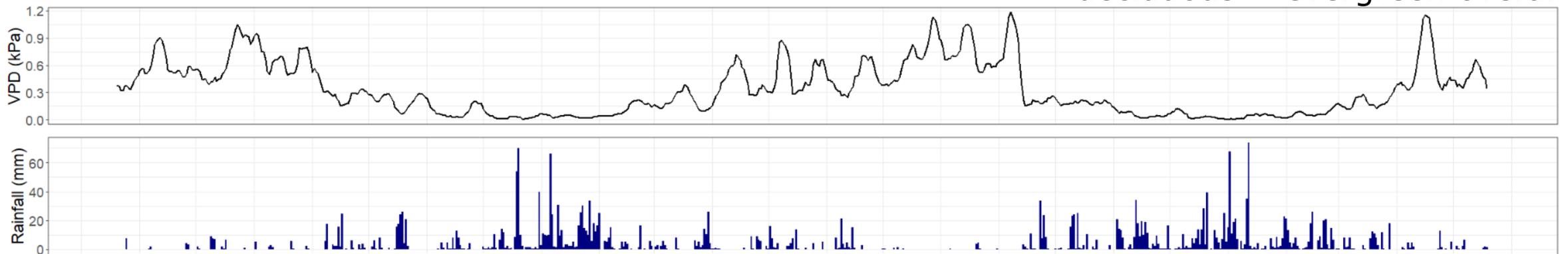
Rainfall (mm)

Transpiration Results (winter/spring '20-'21)

evergreen > deciduous during the early spring

winter/spring mean:

17

15

11

9

Spring rain events
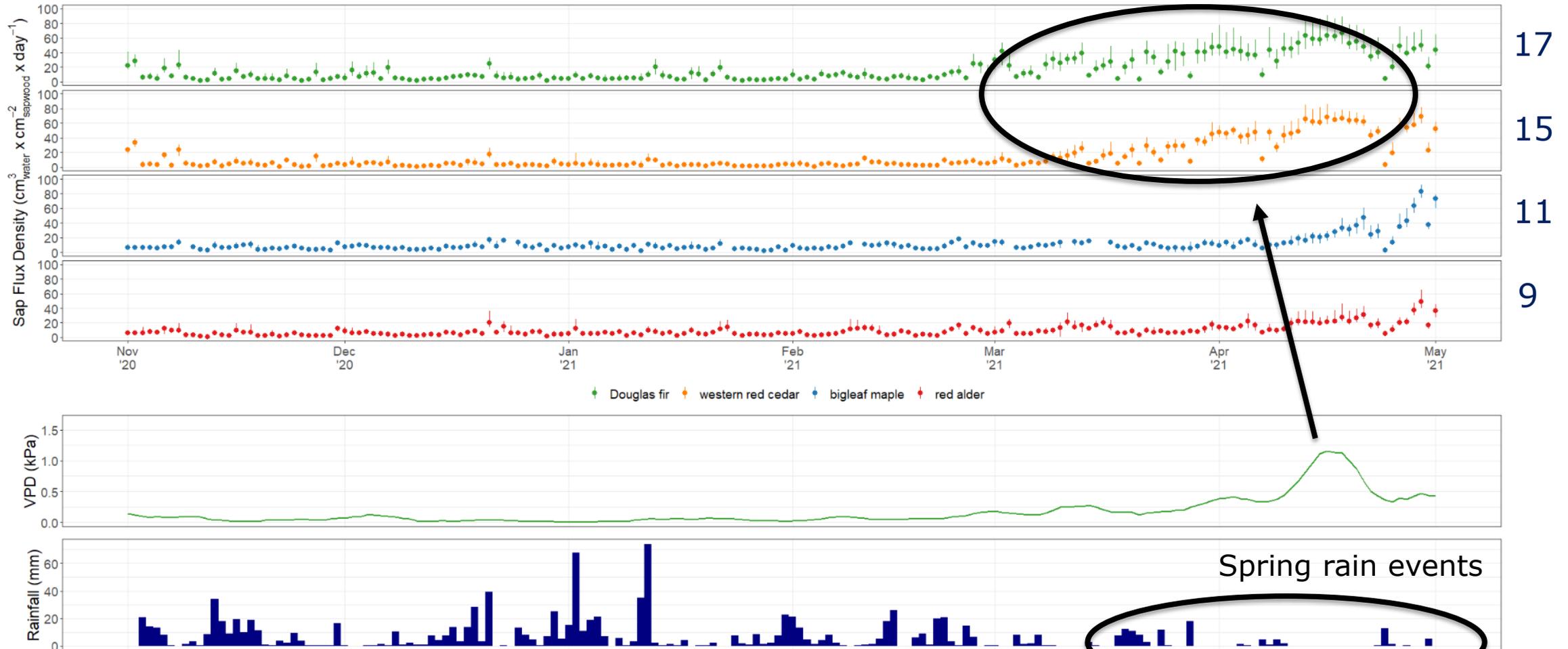
Water Budget for 12 representative trees

› Normalized by Rainfall Depth over Canopy Area

Example Tree Water Budget - % of Annual rainfall
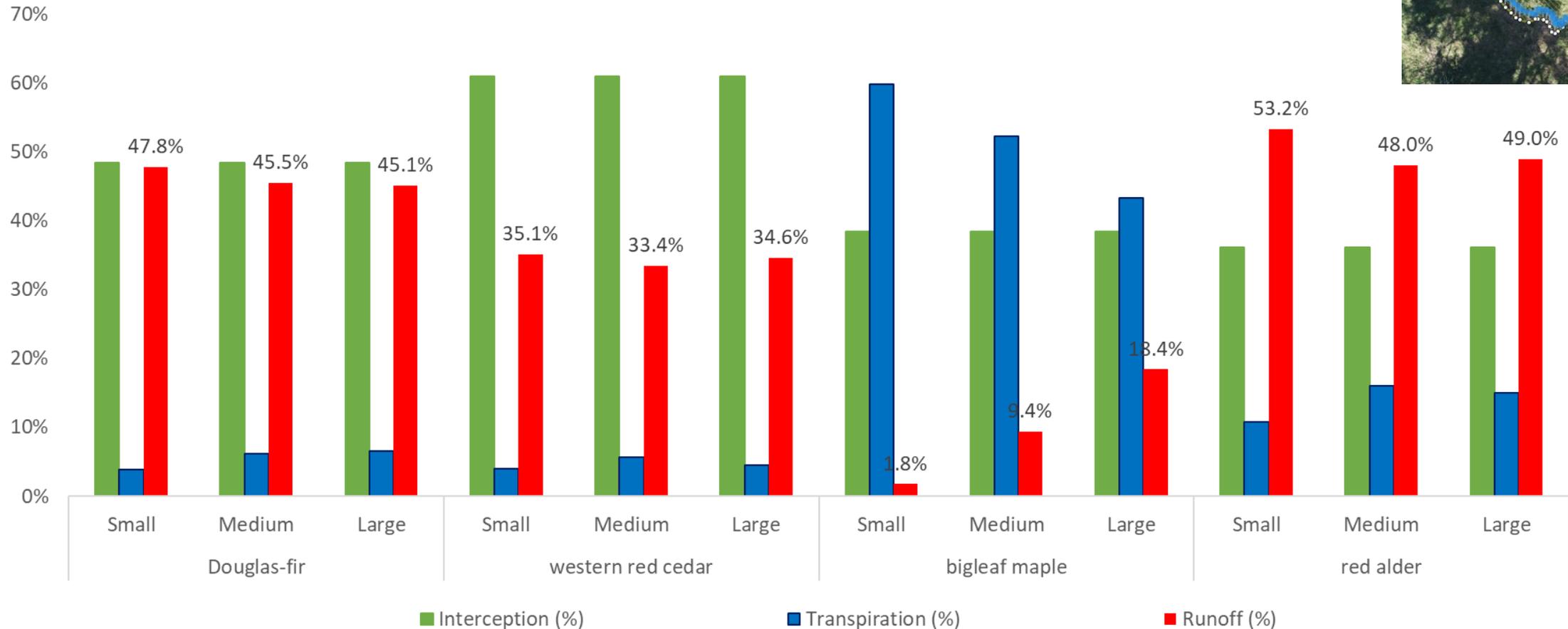
In Asadian & Weiler (2009) interception for Douglas-fir and western red cedar were 49.1 and 60.9% respectively .

Conclusions

❯ Interception

- Stemflow <<< Throughfall

- Red alder – highest stemflow and lowest interception

- Evergreen species – highest interception

- Interception is greatest during lighter rain events

❯ Transpiration

- VPD drives sap flux but this relationship changes seasonally

- Low VPD days are very common in the PNW especially during the winter

- Deciduous transpiration outpaces evergreen overall

- Evergreen species have transpiration benefits during the shoulder season

Next steps

Phase 1

1. Complete sap flux-core data relationship

2. Complete wound-effect assessment

3. Complete Final Report

Phase 2

1. Sap flux instrumentation for younger trees <20 years

2. Focus on trees at The Evergreen State College

Tree Size Distribution

average age = 62 years
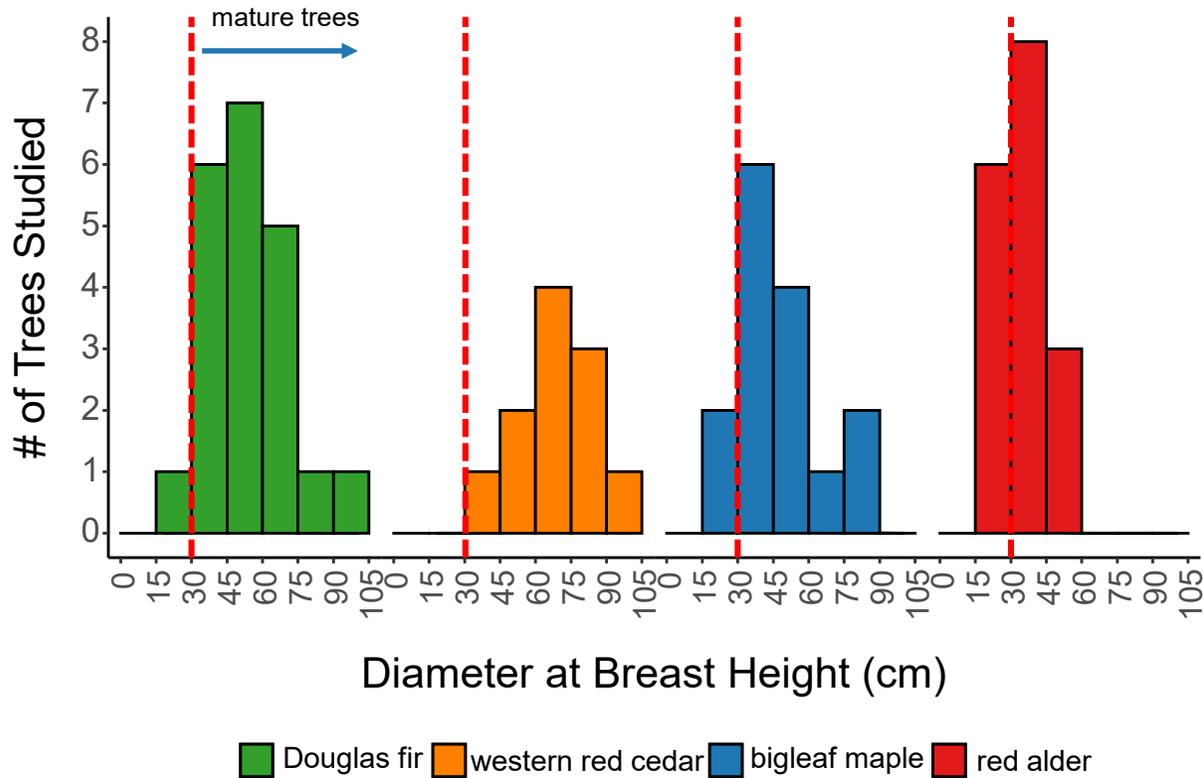
most street trees are less than 15 cm **McPherson et al. (2016)**

Fig. 2. Patterns of street tree age structure from inventories in each climate zone and the "ideal" (IE is Inland Empire, IV is Inland Valleys, NC is Northern California Coast, SC is Southern California Coast, SW is Desert Southwest, IW is Interior West).

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Deliverable schedule

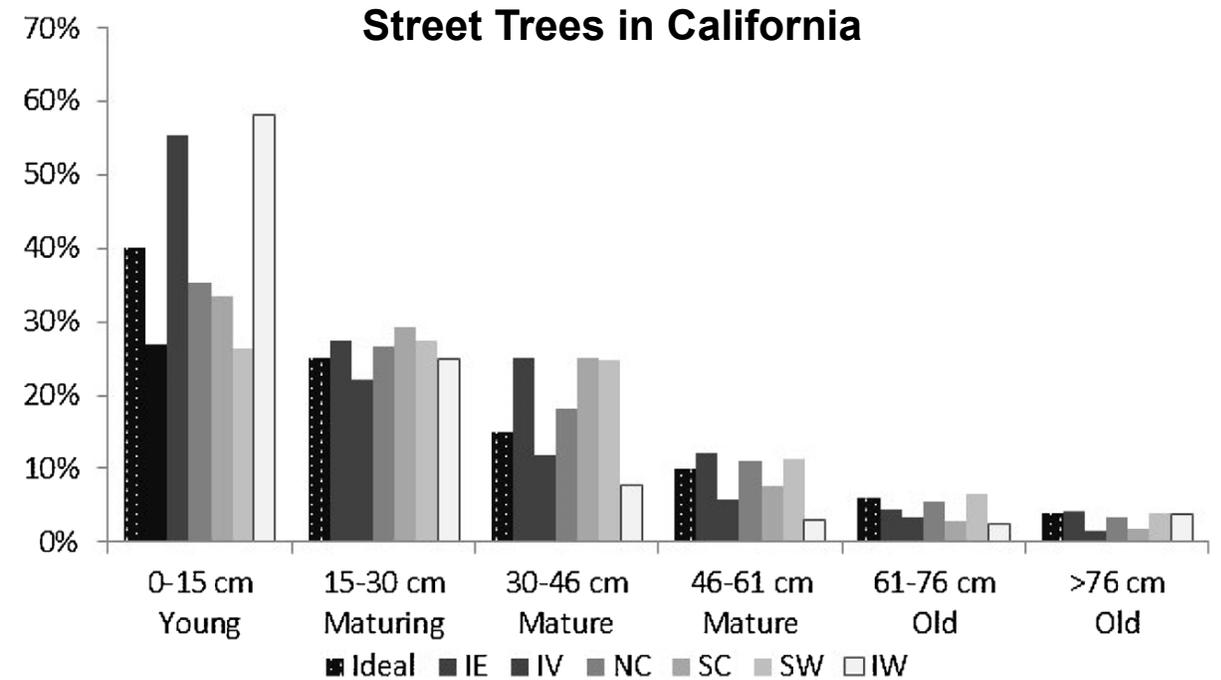| Deliverable by Task	Target Deliverable Date	Target Deliverable Cost	
Task 1.0 Project Management			
D1.1 Semi-annual Progress Report	Jun-22	$ 2,600	
D1.2 Semi-annual Progress Report	Dec-22	$ 2,600	
D1.3 Semi-annual Progress Report	Jun-23	$ 2,600	**DNR**
D1.4 Semi-annual Progress Report	Dec-23	$ 2,600	
D1.5 Semi-annual Progress Report	Jun-24	$ 2,600	
Task 2.0 Planning and QAPP			
D2.1 Draft QAPP amendment	Feb-22	$ 3,106	**WSU**
D2.1 Final QAPP amendment	Mar-22	$ 3,106	
Task 3.0 Instrument Purchase			**WSU**
D3.1 List of instruments purchased	Feb-22	$ 38,165	
Task 4.0 Site Instrumentation			**Evergreen, WSU, Clemson**
D3.1 Installation Memo	Apr-22	$ 27,556	
Task 5.0 Maintenance/Downloads			
D5.1 updates incl. in progress report	Dec-22	$ 18,267	**Evergreen, WSU, Clemson**
D5.2 updates incl. in progress report	Jun-23	$ 18,267	
D5.3 updates incl. in progress report	Dec-23	$ 18,267	
Task 6.0 Data Analyses			**Evergreen, WSU, Clemson**
D6.1 Copy of data in Excel	Jul-24	$ 27,107	
Task 7.0 Communication			
D7.1 Whole Study Draft Report	Aug-24	$ 11,608	
D7.2 Whole Study Final Report	Oct-24	$ 11,608	**Evergreen, WSU, Clemson**
D7.3 Two Presentations	Nov-24	$ 11,608	
D7.4 Draft Fact Sheet	Dec-24	$ 11,608	
Total		**$ 213,273**	

Thank you!

Carly Thompson, Brandon Boyd, Jose Ramirez, Jason Berg - WSU

John Trobaugh and Brian Morris – Nursery Managers, Webster Nursery Farm, WaDNR

Linden Lampman, Andrew Ryan, Miles Micheletti, and Ben Thompson - WaDNR

Keunyea Song- SAM project manager

Budget Phase 2

		DNR	WSU			Evergreen			Clemson				
		Sal+Ben	Sal+Ben	Supplies	Travel	Sal+Ben	Supplies	Travel	Sal+Ben	Supplies	Travel + WA Insurance	All Indirects	Total Task
Task 1	Project Admin	20,000 - *10,000	-	-	-	-	-	-	-	-	-	3,000	**13,000**
Task 2	QAPP amendment	-	4,778	-	-	-	-	-	-	-	-	1,433	**6,212**
Task 3	Instrument purchase	-	-	38,165	-	-	-	-	-	-	-	-	**38,165**
Task 4	Instrument installation	-	4,778	-	1,560	4,741	-	-	8,880	-	2,077	5,520	**27,556**
Task 5	Maintenance and data downloads	-	2,389	-	1,560	30,814	6,000	2,000	-	-	2,077	9,961	**54,801**
Task 6	Data analyses and delivery	-	14,335	-	-	4,741	-	-	1,776	-	-	6,255	**27,107**
Task 7	Outreach and communication	-	21,502	-	-	7,111	-	-	7,104	-	-	10,715	**46,433**
	Totals	**10,000**	**47,783**	**38,165**	**3,120**	**47,406**	**6,000**	**2,000**	**17,760**	**-**	**4,154**	**36,885**	**213,273**

* Dollars left from Phase 1